POWER PLANT ENGINEERING

Established Over 31 Years

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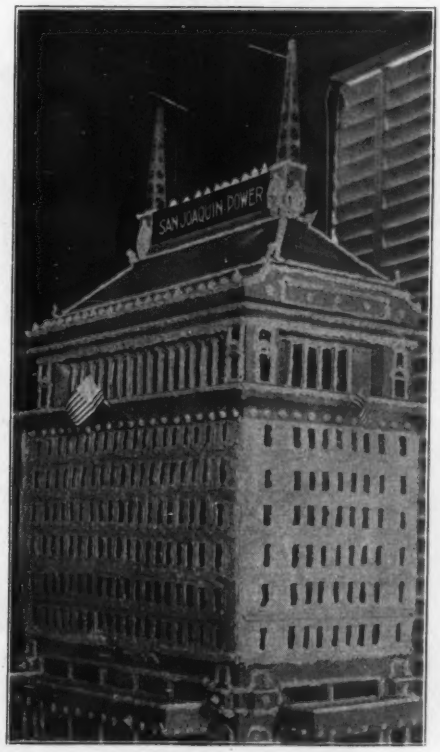


In Xanadu Did Kubla Khan A Stately Pleasure Dome Decree Where Alph, the Sacred River, Ran—

AND SO FORTH. Unfortunately, Mr. Coleridge did not give us floor plans, elevations and specifications of the famous structure which he described so minutely after its erection in the city with the unpronounceable name. Therefore, when the San Joaquin Light & Power Corp. desired to erect a stately pleasure dome by one of the sacred rivers of California, it was forced to use materials different from those employed by the great Khan. So it chose cake and modeled the structure after its 10-story building in Fresno, Calif. The model, weighing 150 lb., was baked in 21 special pans, prepared by the company's experts and was lighted by 121 small flood lights to imitate the original building. The model was 4½ ft. high and covered a floor area of 24 in. by 30 in. It was finally cut into 150 pieces and distributed among employes and friends, who agreed unanimously that when it came to building pleasure domes which really gave pleasure, Kubla had better retire gracefully.

Neches Station Increases Texas Power Facilities

NEW PLANT OF GULF STATES UTILITIES CO., BURNING FUEL OIL AND GAS WITH COMBINATION BURNERS, EMPLOYS EXTRACTION FEED WATER HEATING, GENERATOR AIR COOLERS, WATER COOLED FURNACES, COMBUSTION CONTROLS AND ILLUSTRATES MANY RECENT DESIGN TENDENCIES. BY HENRY W. STRUCK*

RECENT COMPLETION OF THE Neches Power Station marks an important addition to the Gulf States Utilities Co.'s generating facilities in Texas. The station, built by Stone & Webster, Inc., is located approximately 2 mi. from the city of Beaumont, Texas, on the Neches River, which is navigable by sea-going vessels. No wharf facilities are provided, however, as there is no immediate need for them. A spur of the Kansas City Southern Railway has been extended into the station yard and into one end of the turbine room, so that machinery can be handled directly to or from cars by means of the turbine room crane. A newly constructed shell roadway forms another means of access to the station.

The present installation consists of a 21,000-kw. steam turbo-generator unit with two 1530-hp. cross-drum type boilers. The steam pressure is 350 lb. per sq. in. and the total temperature 700 deg. F. The station property is sufficiently extensive to care for an ultimate development of approximately 300,000 kw.

Electrical energy is transmitted by a newly constructed step-up transformer and high tension transmission line system. Several other smaller steam electric generating plants owned and operated by the Gulf States Utilities Co. feed into this system. With the Neches Station in operation, however, these smaller stations will serve only as a standby source of power. Practically all of the power requirements of the community served by the Gulf States Utilities Co. will be taken care of by the more efficient Neches Station.

The building is a steel frame structure resting on concrete foundations on piles. Walls are of brick, floors

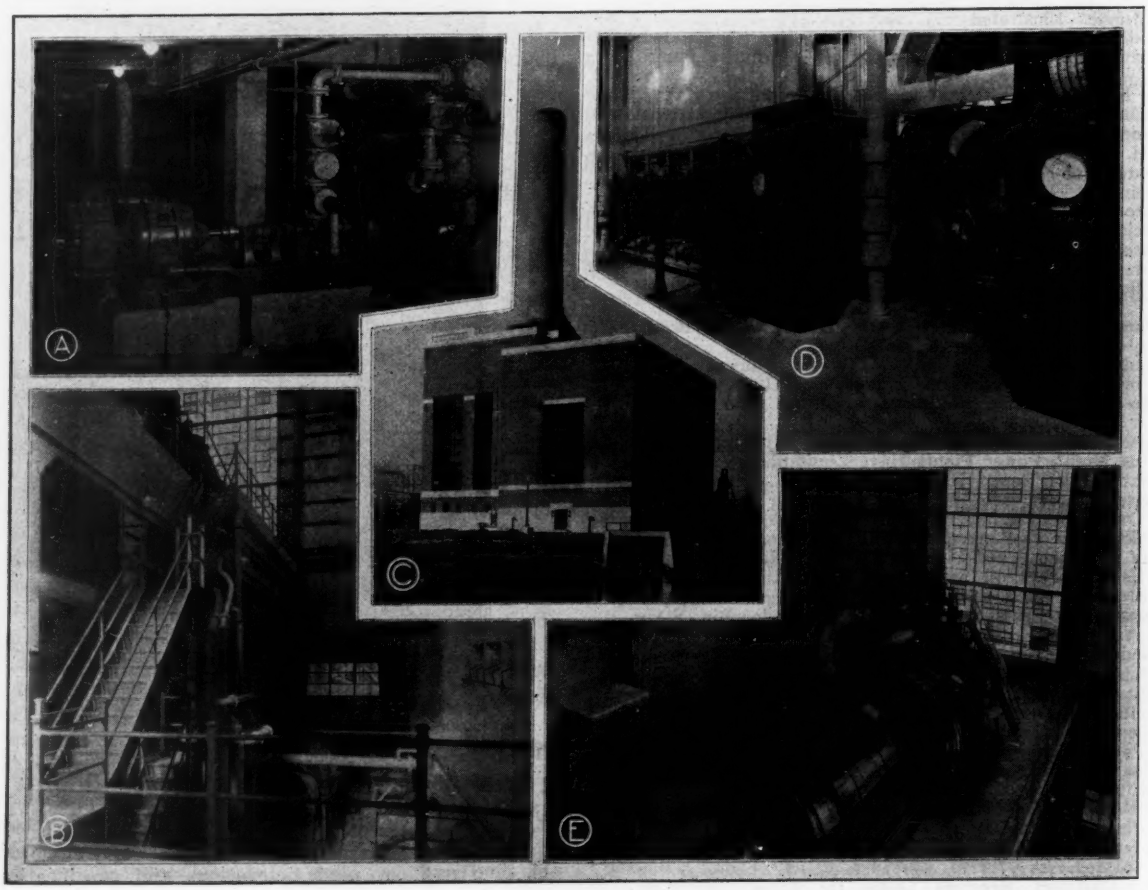


FIG. 1. EQUIPMENT AT NECHES IS ARRANGED FOR ACCESSIBILITY, WHILE DESIGN OF STATION PROVIDES FOR PLENTY OF LIGHT, THUS GIVING IT AN ATTRACTIVE APPEARANCE

A—Fuel oil room contains pumps and heaters equipped with viscosity regulators. B—Turbine room looking west, showing end of condenser, circulating pumps and turbine above. C—General view of plant, discharge flume in foreground. D—Each boiler is fired by eleven combination gas and oil burners; a combustion control panel is provided for each boiler. E—Auxiliary generator, with its exciter, is mounted on the main turbine shaft

*Engineering Dept., Stone & Webster, Inc.

and roof are constructed of concrete and metal sash is used throughout. The turbine room, located next to the river to make the circulating water intake and discharge tunnels as short as possible, is 98 ft. 6 in. long and 60 ft. wide. The boiler room is 99 ft. long and 71 ft. 6 in. wide for the present installation of two boilers and is arranged for boilers on each side of a central firing aisle. Space under the firing aisle is used for the station service switching equipment. All main switching and control equipment is temporarily located on the main turbine platform near the main generator. When the other half of the boiler room is constructed all main switching and control equipment will be located in an electrical bay immediately adjacent to the boiler room.

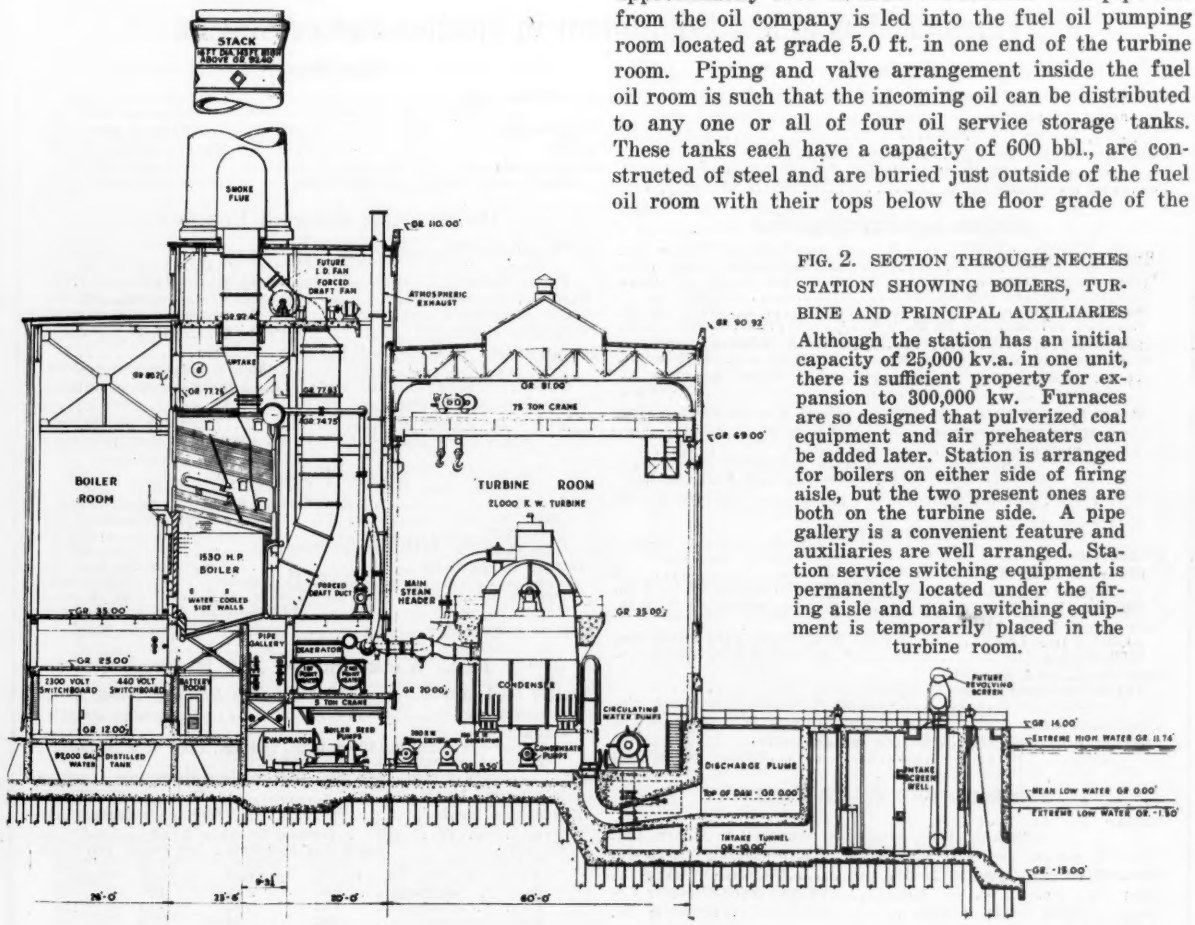


FIG. 2. SECTION THROUGH NECHES STATION SHOWING BOILERS, TURBINE AND PRINCIPAL AUXILIARIES

Although the station has an initial capacity of 25,000 kv.a. in one unit, there is sufficient property for expansion to 300,000 kw. Furnaces are so designed that pulverized coal equipment and air preheaters can be added later. Station is arranged for boilers on either side of firing aisle, but the two present ones are both on the turbine side. A pipe gallery is a convenient feature and auxiliaries are well arranged. Station service switching equipment is permanently located under the firing aisle and main switching equipment is temporarily placed in the turbine room.

Main turbine platform and main boiler room floor are at the same elevation, grade 35.00 ft. The condenser floor, as well as a portion under the boiler room where station auxiliary equipment is located, is at elevation, grade 5.5 ft. Under extreme high water conditions, grade 11.74 ft., this floor will be below river water level. All drainage from the condenser floor is handled by automatically controlled motor driven sump pumps. The station service switching room floor is at grade 12.00 ft., so that this room will always be above river water level.

This station is designed to burn natural gas with fuel oil as a standby. The station is also designed so that equipment for burning pulverized coal can be installed. Natural gas having approximately 950 B.t.u. per cu. ft. is taken from the mains of the Magnolia Pipe Line Co. at a distance of approximately 8500 ft. from the station. The gas delivery pressure is approximately 125 lb. gage and is reduced in two steps by means of reducing valves, located just outside of the station, to approximately 10 lb. gage for delivery to the burners.

Fuel oil having approximately 18,000 B.t.u. per lb. is taken from the pipe line of the Magnolia Refining Co., approximately 8500 ft. from the station. The pipe line from the oil company is led into the fuel oil pumping room located at grade 5.0 ft. in one end of the turbine room. Piping and valve arrangement inside the fuel oil room is such that the incoming oil can be distributed to any one or all of four oil service storage tanks. These tanks each have a capacity of 600 bbl., are constructed of steel and are buried just outside of the fuel oil room with their tops below the floor grade of the fuel oil room. A steam coil suction heater is provided for each tank.

Fuel oil pumping equipment consists of one 30-g.p.m. steam-turbine-driven pump and one 30-g.p.m. and one 60-g.p.m. variable-speed motor-driven pumps. Two 30-g.p.m. and one 60-g.p.m. fuel oil heaters are provided for heating the oil to the proper viscosity before delivery to the burners. A viscosity regulator is used to control the steam supply to heaters for holding a constant viscosity on the oil delivered to the burners.

Combustion System

Burner equipment in the boiler furnaces consists of 11 combination gas and oil burners per boiler. Air for combustion is supplied for each boiler by two 30,000-c.f.m. forced draft fans. The fans are each direct connected to variable speed slip ring motors and are located on a floor over the boilers. A concrete super-

imposed stack 16 ft. in diameter at top and 200 ft. high above main firing floor is provided to remove the gases from three boilers. In the future it is planned to preheat the air for combustion and the boiler plant is designed for the installation of air preheater and induced draft fan equipment necessary for this purpose. Combustion control equipment is provided for automatically regulating the furnace air supply and furnace draft conditions for variations in steam pressure.

Boilers are encased in a solid fire brick setting built up on the furnace water wall construction.

Main and auxiliary steam systems are designed for 400 lb. using Sargol welded joints. The auxiliary steam system is divided into two sections. The first section supplies 350-lb. steam to various standby steam driven auxiliaries such as boiler feed pump and exciter. The second section takes steam through a reducing valve from the first section and delivers 175-lb. steam for fuel

Principal Mechanical Equipment in Neches Power Station

General

Location....On Neches River, 2 mi. south of Beaumont, Tex.
Character of service....Central station
Capacity, present building....21,000 kw.
Capacity, ultimate....Property suitable for 300,000 kw. development
Designed and built by....Stone & Webster, Inc.

Boilers and Superheaters

Boilers....Babcock & Wilcox Co.
Type of boiler....Cross-drum water tube
Operating pressure....350 to 375 lb. gage
Heating surface per boiler....15,300 sq. ft.
Furnace volume....8050 cu. ft.
Furnace volume, per sq ft. h.s....0.526 cu. ft.
Superheater....Babcock & Wilcox interdeck
Superheating surface, per blr....3712 sq. ft.
Sq. ft. superheating surface, per sq. ft. boiler heating surface....0.243
Steam temperature....700 deg. F. at 200 per cent rating
Corresponding superheat....258 deg. F. at 375 lb. gage
Type of water walls....Tubes and headers with refractory faced cast iron block on rear and side walls and furnace floor
Water wall heating surface per boiler....1440 sq. ft.

Boiler Settings

Dimensions—
Floor to bottom of front header....22 ft.; to C.L. drum, 39 ft. 9 in.
Furnace length....17 ft. 1 in., width 22 ft. 3 in.
Fire brick, 1st quality—
44,000 Acme brick....Evens & Howard Fire Brick Co.
3000 Mizzou tile....A. P. Green Fire Brick Co.
Fire brick, 2nd quality—
47,000 Texafrax Class A brick....Evens & Howard Fire Brick Co.
Insulating brick—2300....Armstrong Cork & Insulation Co.
Refractory-faced c.i. blocks for water walls....Bailey Meter Co.

Miscellaneous Boiler Fittings

Safety Valves, 6—4½-in....(Consolidated), Manning, Maxwell & Moore, Inc.
Blowoff cocks, 2—2½-in....Everlasting Valve Co.
Blowoff valves, Type B, 2—2½-in....Yarnall-Waring Co.
Soot blowers—12 pr. per boiler....Vulcan Soot Cleaner Co.
Gage glasses, vertical type....Ernst & Co.
Water columns....The Stets Co.
Feed water regulators, Type B....The Stets Co.

Fuel Oil Supply

Received from....Magnolia Refining Co.'s pipe line
Service tanks, number....4
Capacity....600 bbl. each
Material....Steel
Meter....."Niagara," Buffalo Meter Co.

Gas Supply

Receiving line....12-in. line at 100 lb. pressure—Reduced to 10 lb.
Regulators....The Chaplin-Fulton Mfg. Co.
Meter....."Westcott," Metric Metal Works

Fuel (present)	Untopped fuel oil	Natural gas
Heat value, B.t.u.	18,000 per lb.	940 to 1000 per cu. ft.

Oil and Gas Burning Equipment

Fuel oil pumps....W. E. Quimby, Inc., 2—30 g.p.m., 1—60 g.p.m.
Type..Rotary, 2 motor-driven, 1—30 g.p.m. turbine driven
Fuel oil heaters....The Griscom-Russell Co.
Oil conditions....300 lb. pressure, 250 deg. F.
Viscosity regulator....Peabody Engineering Corp.
Combination gas and oil burners....Peabody Engineering Corp.
Type...Peabody-Fisher wide range, mechanical atomizing
Number per boiler....11
Maximum capacity....21,700 cu. ft. gas per burner per hour, 1430 lb. oil per burner per hour

Draft Equipment

Chimney....Reinforced concrete, superimposed
Built by....Heine Chimney Co.
Diameter....16 ft.
Height above boiler room floor....200 ft.
Forced draft fans....American Blower Co.
Type....No. 6½ H.S. double inlet, full housed
Driven by....50-hp., 2200-v. G.E. slip-ring motors
Capacity, each....30,000 c.f.m. at 6 in. of water
Boiler breechings....Houston Structural Steel Co.

Feed Water Pumps and Heaters

Boiler feed pumps....Worthington Pump & Mach. Corp.
Number....3 (Jeanesville)
Capacity—
Motor-driven (2)..600 g.p.m., 250 hp., 2200 v. G.E. motors
Turbine-driven (1)....600 g.p.m., 243 hp., 350-lb. Westinghouse turbine
Discharge head....450 lb.
Extraction heaters....The Griscom-Russell Co.
Type....4-pass, floating head, closed type

Designation	1st Point	2nd Point	3rd Point	4th Point
Surface, sq. ft....	1260	1275	1060	1120
Water, per hr., lb..	312,570	312,570	256,460	225,000
Deg. F. entering..	305	240	156	88
Deg. F. leaving...	372	305	220	156
Abs. pressure, lb..	203	90	23.4	20

Deaerator....Cochrane Corp.
Steam pressure, normal...18 to 22.4 lb. abs. (Drips from evaporator coils and vapor from 2nd effect evaporator, 1st and 2nd point heaters and main steam drips.)
Capacity (lb. per hr.)....300,000 normal
Water temperature....205 deg. F. inlet
Steam required per hr., lb....44,350 normal
Evaporator....The Griscom-Russell Co.
Type....Two effect, high heat level
Steam taken from....2nd point from main turbine

Furnace construction is of the water cooled type with refractory faced blocks. Both side and rear walls and furnace bottom are constructed thus. The front wall is of refractories and is of a ventilated type of construction.

Steam is generated in two 1530-hp. cross-drum boilers. These boilers are 39 tubes wide and 16 tubes high. Tubes are arranged in a lower deck 6 tubes high and an upper deck 10 tubes high. A triple loop superheater is placed between upper and lower tube decks.

oil heating purposes and for operation of standby steam driven fuel oil pump and main condenser steam air jets.

High pressure drips are piped to a common receiver from which they are expelled through a motor-operated valve into a deaerator forming part of the feed water system. This valve is operated through a mercury column electric contactor arrangement controlled by level of water in the receiver.

The main turbine is of the combination type with two rows of impulse and 58 rows of reaction blading.

Turbine speed is 1800 r.p.m. and it is direct connected to a 25,000-kv.a., 80 per cent power factor, 13,200-v., 60-cycle main generator. A 1250-kv.a., 2300-v. station auxiliary generator, together with its exciter, is direct connected to the main generator shaft. Station service transformers, energized by the main power supply bus, are provided as a standby for the auxiliary generator.

Air cooling system for both the main and auxiliary generators is of the closed type using surface type air coolers. Water direct from the Neches River is used for a cooling medium and is delivered to the coolers by a motor driven pump. In case of break-down to this pump, water may be taken direct from the station service water system.

The main turbine has a self-contained oil pump for circulating oil to the bearings. An auxiliary steam turbine driven oil pump is also provided for emergency use. Oil coolers are provided in duplicate for cooling the oil. Water discharged from the generator air coolers serves to cool the oil in the oil coolers. A continuous bypass type oil filtering equipment is provided directly at the unit. Filter equipment, together with clean and dirty oil storage tanks, is provided in an oil room at the end of the turbine room for filtering and purifying the oil used for the main unit. Oil is transferred to the oil room from the unit through a piping system provided for that purpose.

Steam from the main turbine is condensed in a 35,000-sq. ft. surface condenser of the two-pass, two-compartment type. This condenser is suspended from the turbine exhaust flange, supplemented by spring supports on solid foundation below. Two slip-ring motor operated circulating pumps supply cooling water to the condenser. One of these pumps operating alone delivers 26,000 g.p.m. while both pumps operating together deliver 44,000 g.p.m. Constant-speed-motor-operated, two-stage, condensate pumps, as well as two-stage steam-jet air removal equipment, are provided

Principal Mechanical Equipment in Neches Power Station—Cont'd

Prime Mover, Condenser and Auxiliaries

Turbo-generator	Westinghouse Electric & Mfg. Co.
Type	Single cylinder, impulse-reaction single flow, with multiple exhaust blading; 2 rows impulse, 58 rows reaction blading
Capacity—	
Turbine	21,000 kw.
Main generator	20,000 kw., 25,000 kv.a., 13,200 v., 60-cycle, 3-phase.
Auxiliary generator	1000 kw., 1250 kv.a.
Speed	1800 r.p.m.
Surface condenser	Westinghouse Electric & Mfg. Co.
Type	Two pass, two compartment, radial flow
Tube surface	35,000 sq. ft.
Tube surface per kw. main generator rating	1.75
Lb. steam per sq. ft. per hr. (no bleeding)	6
Tubes, composition	Admiralty, by cupping process
Tube maker	Wheeler Condenser & Eng. Co.
Circulating Water Pumps (2)	Westinghouse Electric & Mfg. Co.
Capacity one pump running, 26,000 g.p.m.; two running, 44,000 g.p.m.	
Driven by	200 hp., 2200-v., slip ring motors
Condensate Pumps	2 (Westinghouse Electric & Mfg. Co.)
Capacity, each	600 g.p.m. (300,000 lb. per hr.)
Driven by	60-hp. constant speed motors
Air Removal Equipment	2 units (Westinghouse Electric & Mfg. Co.)
Type	Steam jet with surface inter and after-condenser
Number of elements	2 per unit
Capacity per unit	80 lb. air per hr. at 70 deg. F.
Generator Air Coolers	The Griscom-Russell Co.
Type	U-fin surface
Exciters	Westinghouse Electric & Mfg. Co.
Voltage	Generators 250 v. d.c., motors 2200 v.
Turbine and motor-driven exciter	200 kw.
Motor-driven exciter	150 kw.
Turbine Room Crane	Northern Engineering Works
Capacity (tons)	Main hoist 75, auxiliary hoist 15
Water Screen	Link-Belt Co.
Type	Vertical, revolving
Width	9 ft. 8 in.
Sluice Gates	Coffin Valve Co.

Miscellaneous Pumps

Following Centrifugal Pumps supplied by Worthington Pump & Machy. Corp., driven by 440-v. General Electric Co. induction motors.

Service pump (1)	Single suction, two stage
Capacity	100 g.p.m., 10-hp. motor
Emergency service pumps (1)	Dougle suction, single stage
Capacity	650 g.p.m., 40-hp. motor
Auxiliary air cooler pump (1)	Double suction, single stage
Capacity	650 g.p.m., 20-hp. motor
Distilled water pump (1)	Vertical, single stage
Capacity	600 g.p.m., 25-hp. motor
Waste sump pumps (2)	Vertical, single stage
Capacity (each)	100 g.p.m., 2-hp. motor
Clean sump pumps (2)	Vertical, Axiflo—No. 6
Capacity (each)	100 g.p.m., 7½-hp. motors
Evaporator feed pumps (2)	Single suction, two stage
Capacity (each)	50 g.p.m., 7½-hp. motors
Drip pump for ext. heater (1)	Single suction, two stage
Capacity	100 g.p.m., 15-hp. motor
Evaporator coil drip pump	Double suction, single stage
Capacity	30 g.p.m., 3-hp. motor
Fire pump (1)	8-in. double suction, single stage
Capacity	750 g.p.m., 75-hp., 2200-v. motor

Tanks

Raw water surge tank	Concrete, 12,000 gal. (in base of chimney)
Distilled water surge tank	8200 gal. (Cochrane Corp.)
Type	Cast iron (part of deaerator equipment)
Distilled water storage tank	Concrete, 92,000 gal.
Transformer oil storage tank	Coatesville Boiler Works
Capacity, gal.	1—10,000 and 1—6000, steel
Circuit breaker oil storage tank	Coatesville Boiler Works
Type	Steel, 3000 gal.

Miscellaneous Equipment and Materials

Building steel (1060 t.)	Pennsylvania Car Co.
Skylights and louvres	The G. Drouve Co.
Stairways and walkways	Houston Struct. Steel Co.
Grating	Wm. F. Klemp Co.
Ventilators	The G. Drouve Co.
Circulating water piping	Kutztown Foundry & Machine Co.
Circulating water valves	Chapman Valve Mfg. Co.
Circulating water expansion joints	United States Rubber Co.
Air compressor	Ingersoll-Rand Co.
Lubricating oil system—	
Oil coolers	Andale Engineering Co.
Filters and transfer pump	S. F. Bowser & Co., Inc.
Oil purifier	De Laval Separator Co.
High pressure steam system—	
Gate and globe valves	Pittsburgh Valve, Foundry & Const. Co.
Boiler nonreturn valves	Pittsburgh Valve, Foundry & Const. Co.
Pipe and fittings	Pittsburgh Valve, Foundry & Const. Co.
Low pressure steam and water systems—	
Gate valves	Chapman Valve Mfg. Co.
Check valves	Chapman Valve Mfg. Co.
Pipe and fittings	Pittsburgh Valve, Foundry & Const. Co., Grinnell Co., Lumsden & Van Stone Co.
Copper expansion joints	E. B. Badger & Sons
Atmospheric relief system—	
Valve	Atwood & Morrill Co.
Pipe	Kutztown Foundry & Machine Co.
Spiral riveted pipe	Abendroth & Root Mfg. Co.
Ventilating fans (3)	American Blower Co.
Capacity, c.f.m.	320, 940 and 5400

Instruments

Boiler feed meter	Simplex Valve & Meter Co.
Thermometers—	
Indicating	Taylor Instrument Co.
Recording	Brown Instrument Co.
Gages—	
Indicating	Manning, Maxwell & Moore
Recording	Brown Instrument Co.
Liquid level	Foxboro Co.
Combustion control system	Bailey Meter Co.
Type	Part manual arranged for future full automatic
Panel boards	One for each boiler
Instruments	On each panel board 1—Bailey boiler meter; 1—4 pointer draft gage; 1—air and steam flow meter and damper control.

in duplicate. Water for the circulating pumps is taken direct from the Neches River and is delivered to the pumps through a system of concrete tunnels from a screen well outside of the station. Water discharged from the condenser is led through a system of concrete tunnels to a concrete flume outside the station and thence to the river.

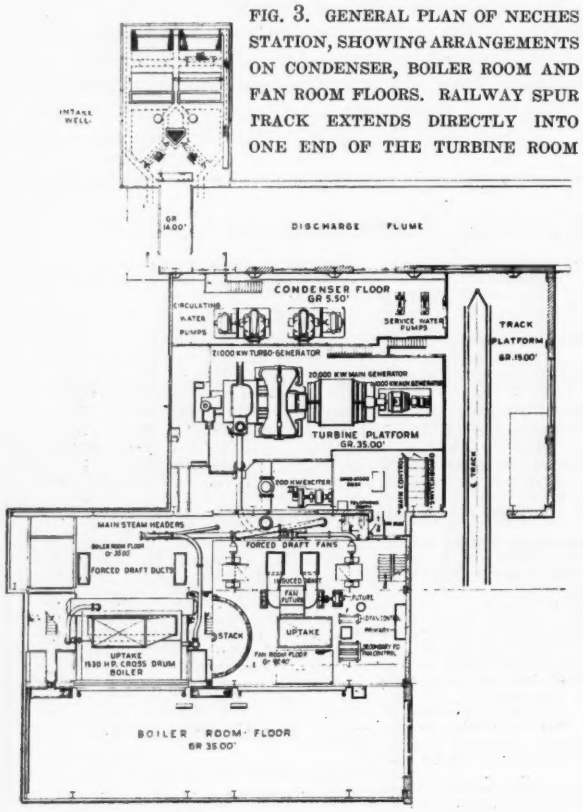


FIG. 3. GENERAL PLAN OF NECHES STATION, SHOWING ARRANGEMENTS ON CONDENSER, BOILER ROOM AND FAN ROOM FLOORS. RAILWAY SPUR TRACK EXTENDS DIRECTLY INTO ONE END OF THE TURBINE ROOM

Feed Water System

Main source of feed water supply for the boiler is condensate from the main turbo-generator. Make-up water to the feed system is distilled water taken from a 92,000-gal. concrete storage tank located under the boiler room basement floor and drawn directly to the condenser hot well by the vacuum in the condenser.

Condensate pumps deliver the main turbine condensate, together with what make-up is introduced, through two closed heaters supplied with steam extracted from the low pressure end of the main turbine. After the water leaves these heaters it passes to a direct contact, positive pressure type deaerator. Before the water enters the deaerator it passes through a small surface type condenser which condenses the vapors vented from the deaerator.

This deaerator is mounted directly on top of a square, cast-iron surge tank having a capacity of approximately 8000 gal. After passing through the deaerator the water flows into the surge tank, thence directly to the boiler feed pump suctions.

Feed water enters the deaerator below the boiling point at atmospheric pressure. In order to flash the water for deaeration, steam is supplied to the deaerator in the form of vapor from a positive pressure evaporator plant, drips from two high pressure closed feed water heaters and drips from main and auxiliary steam systems. Pressure in the deaerator is always a few

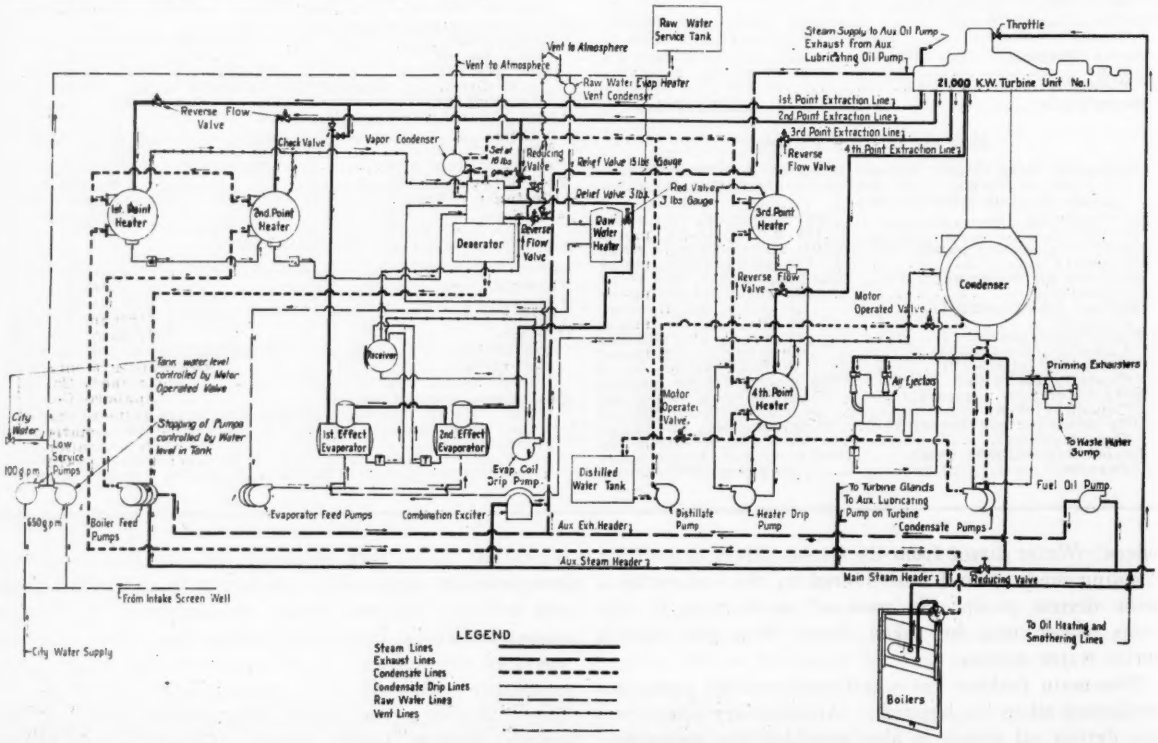


FIG. 4. STATION FLOW DIAGRAM SHOWS CIRCUITS OF STEAM, RAW WATER, CONDENSATE AND EXHAUST LINES THROUGH THE ENTIRE PLANT

pounds above atmospheric and if for any reason any of the above sources of steam supply are cut off or in case there is an insufficiency of steam from these sources, steam is admitted automatically through a reducing valve. This steam is taken from the next to the highest point on the turbine. This extraction point also serves as the normal supply for the evaporators as well as another closed feed water heater. A still higher extraction point supplies steam to another closed type feed water heater. This steam also serves as a secondary steam supply for the evaporators which can be used in case more output from the evaporators is required. The piping arrangement of the evaporators is such that the plant, consisting of two shells, can be operated either single or two effect off either of the above extraction points.

Emergency make-up water, in case of condensate pump failure or other failures in the feed water system up to the deaerator, is supplied direct by a motor-operated pump taking suction from the distilled water tank and delivering it to the feed system before entering the deaerator.

Three centrifugal boiler feed pumps are provided, one turbine-driven and two driven by constant-speed, slip-ring motors. Each pump has sufficient capacity to feed the boilers with full load on the main turbo-generator unit. The feed water pumps deliver the water through the two extraction heaters taking steam from the high pressure end of the unit. Water level in the boiler drums is controlled by feed water controllers.

Both Beaumont City water and Neches River water are available for station service use. A 6-in. main approximately 10,000 ft. long has been installed for the city water service supply. Water from the Neches River is taken from an extension of the circulating water intake tunnel and is delivered by motor-driven pumps to a water storage tank incorporated in the base of the chimney.

Normally the station service water is used for general house service, cooling of bearings on the various auxiliaries and sealing glands of the various auxiliaries, where the use of this water is suitable. Where there is danger of sealing water entering the feed system, condensate from the main turbine is used. All bearing cooling water is returned to a sump from which it is pumped by automatic sump pumps to the raw water storage tank.

All standby steam driven auxiliaries exhaust into an auxiliary exhaust piping system, normally discharging into the deaerator. Any exhaust which cannot be used in the deaerator discharges through a back pressure valve direct to the atmosphere.

All pumps are connected to a priming system and steam air jets are provided for creating the vacuum throughout the system.

A 300-c.f.m., motor-driven air compressor together with receiver is provided for serving the station compressed air system. Outlets with hose connections are provided at all important points throughout the station where compressed air may be required for cleaning or maintenance work.

A portable Foamite extinguisher is provided for the fuel oil pump room. This room, as well as the lubricating oil room and fuel oil tanks, is provided with steam smothering lines. The station proper and the main and auxiliary generators are protected against fire by a water system.

Obtaining Economical System Operation

DIVISION-OF-LOAD REPORT AND ITS COMPILATION, DETERMINING PERFORMANCE, NECESSITY OF ACCURATE INSTRUMENTS. BY H. M. COOK*

ONE OF THE MOST important features of operating practice is attaining and maintaining economy of operation. Different plants and companies use various methods which are followed more or less systematically with varying degrees of success, thus the degree to which different companies participate in work of this kind is most astounding. It varies all the way from absolute disregard to an earnest, conscientious and systematic attempt to do the utmost possible with the available equipment.

It is a practice of the Brooklyn Edison Co. so to operate its different stations and so to distribute the load among them that the total kw-hr. output of this system is generated at the least possible cost. In attaining this goal, it is often necessary deliberately to sacrifice the operation of the most economical station and operate it at a less economical figure than possible.

The Brooklyn Edison System consists of one 25-cycle and two 60-cycle generating stations which are tied together through a 35,000-kw. synchronous type frequency changer. For insurance of continuity of operation the rule has been adopted that sufficient excess capacity be carried on the bus at all times so that in case of sudden failure of the largest unit the remaining machines will carry the load. Under these conditions a wide range of choice in loading and extremely accurate scheduling of apparatus becomes absolutely necessary to obtain maximum economy of operation. Data must be compiled so that economic scheduling of the allotment of load to the different generating stations can be made at all times.

DIVISION OF LOAD REPORTS

A division of load report containing all of the necessary data for daily scheduling the proper division of load among the generating stations and among the machines in each station is assembled each year for the ensuing year. This report is compiled in the following manner.

The Willans line is plotted for each individual machine in the station. From the Willans line, input-output curves are made up for each machine, taking boiler efficiency and auxiliary power consumption into consideration. From the input-output curve, first derivative curves for the different units obtained by plotting increment increases in coal consumption against unit increases in load. Curves A and B, Fig. 1, show the

*Engineer of Tests, Brooklyn Edison Co. Abstract of a paper presented at a meeting of the Metropolitan Section of the A. S. M. E., New York, January 31, 1927.

first derivative curves of a 50,000 and an 80,000-kw. unit respectively. Load division curves for each pair of machines in the station are then plotted from the first derivative curve. A type of loading curve is shown in Fig. 2. A similar analysis is then made for the other generating stations in the system.

The next step is the compilation of input-output curves of various combination of units in the station. The input-output curves and loading curves of the individual units are used in computing the combination input-output curve. A sample of these curves is shown in Fig. 3. Coal rate curves for the same combinations are shown in Fig. 4. Similar curves of input-output and coal rate must then be drawn up for the other generating stations. The same procedure is followed out in the station combination of units as was described

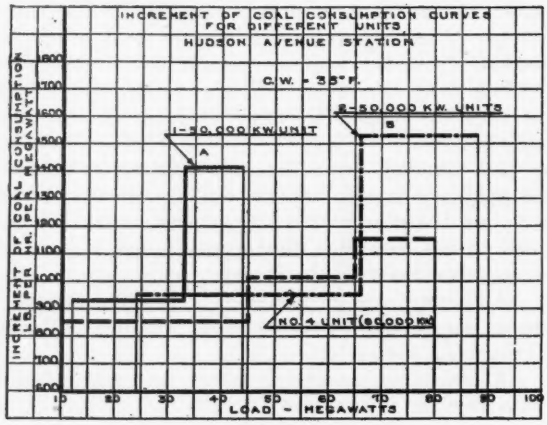

INCREMENT OF COAL CONSUMPTION CURVES FOR DIFFERENT UNITS
HUDSON AVENUE STATION
C.W. - 35° F.
2-50,000 KW. UNITS
1-50,000 KW. UNIT
NO. 4 UNIT (80,000 KW.)
LOAD - MEGAWATTS

FIG. 1

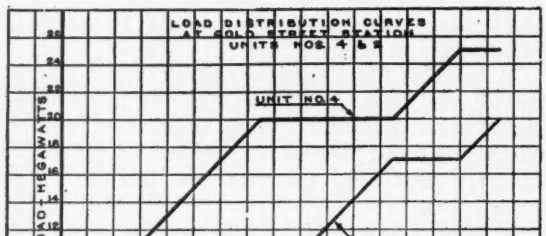

LOAD DISTRIBUTION CURVES AT GOLD STREET STATION UNITS NOS. 4 & 2
UNIT NO. 4
UNIT NO. 2
UNIT NO. 2 - 25,000 KW.
UNIT NO. 4 - 30,000 KW.
STATION LOAD - MEGAWATTS

FIG. 2

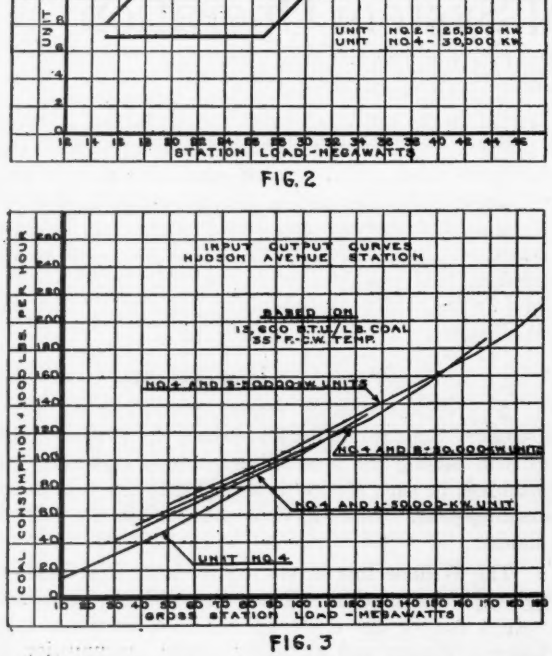

INPUT OUTPUT CURVES HUDSON AVENUE STATION
BASED ON 13,600 B.T.U./LB. COAL 35° F.-C.W. TEMP.
NO. 4 AND 2-50,000 KW. UNITS
NO. 4 AND 2-30,000 KW. UNITS
NO. 4 AND 1-50,000 KW. UNIT
UNIT NO. 4
GROSS STATION LOAD - MEGAWATTS

FIG. 3

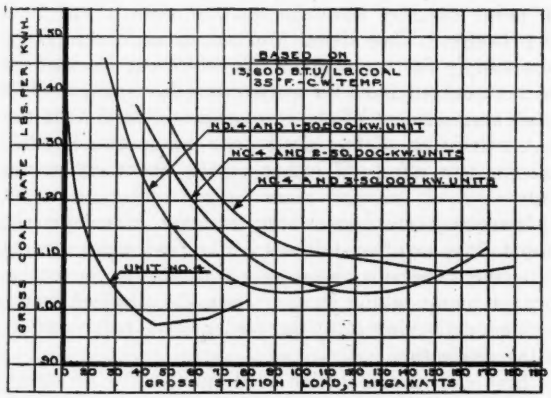

BASED ON 13,600 B.T.U./LB. COAL 35° F.-C.W. TEMP.
NO. 4 AND 1-50,000 KW. UNIT
NO. 4 AND 2-50,000 KW. UNITS
NO. 4 AND 3-50,000 KW. UNITS
UNIT NO. 4
GROSS STATION LOAD - MEGAWATTS

FIG. 4

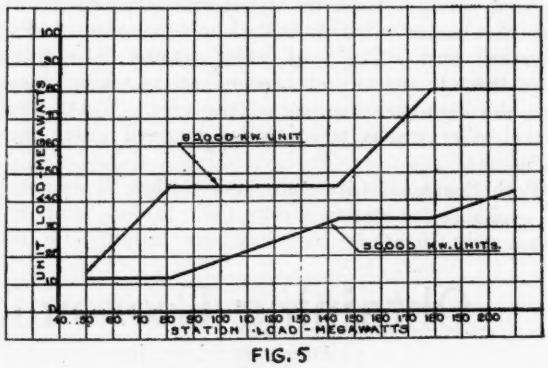


FIG. 5

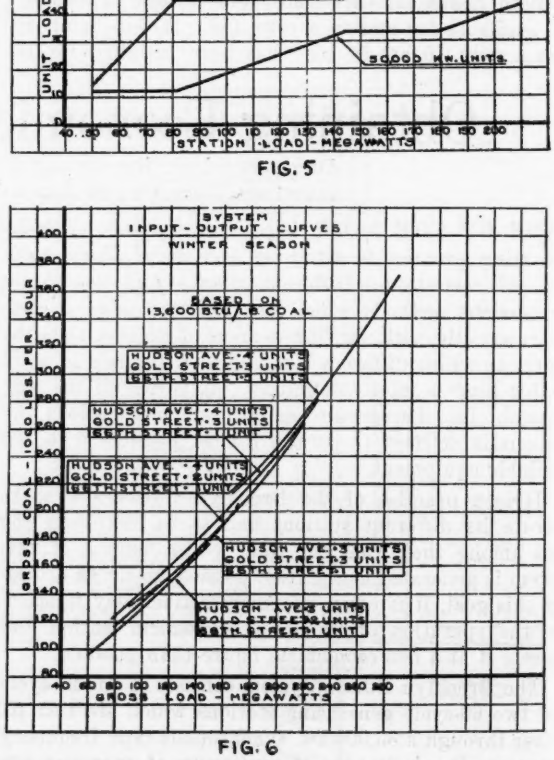

SYSTEM INPUT - OUTPUT CURVES WINTER SEASON
BASED ON 13,600 B.T.U./LB. COAL
HUDSON AVE. - 4 UNITS GOLD STREET - 3 UNITS 58TH STREET - 1 UNIT
HUDSON AVE. - 4 UNITS GOLD STREET - 3 UNITS 58TH STREET - 0 UNIT
HUDSON AVE. - 4 UNITS GOLD STREET - 2 UNITS 58TH STREET - 1 UNIT
HUDSON AVE. - 3 UNITS GOLD STREET - 3 UNITS 58TH STREET - 1 UNIT
HUDSON AVE. - 3 UNITS GOLD STREET - 2 UNITS 58TH STREET - 1 UNIT
GROSS LOAD - MEGAWATTS

FIG. 6

FIG. 1. INCREMENT OF COAL COSUMPTION CURVES FOR DIFFERENT UNITS, HUDSON AVE. STATION. FIG. 2. LOAD DISTRIBUTION CURVES AT GOLD ST. STATION, UNITS NOS. 4 AND 2 FIG. 3. INPUT-OUTPUT CURVES, HUDSON AVE. STATION. FIG. 4. GROSS COAL-RATE CURVES, HUDSON AVE. STATION. FIG. 5. LOAD DISTRIBUTION CURVES AT HUDSON AVE. STATION. FIG. 6. SYSTEM INPUT-OUTPUT CURVES, WINTER SEASON

for the individual units in the station. Therefore, first derivative curves of the combination and then loading curves of the combination are computed. Figure 5 illustrates the combination loading curve.

With the data thus collected, the input-output curves are compiled for various assumed combinations of units on the system. In making up the combinations the most economical units of the different stations are first selected and then the units which are next most economical. The maximum operating range of these combinations is determined by the total capacity minus the capacity of the largest unit according to the operating rules previously cited. Input-output curves of the system combinations are shown in Fig. 6 and system combination coal rate curve in Fig. 7. Loading curve between the two largest stations for two different combinations are shown in Figs. 8 and 9. The data on which the curves are based are taken from the latest turbine and boiler tests and actual turbine room and boiler room performance records.

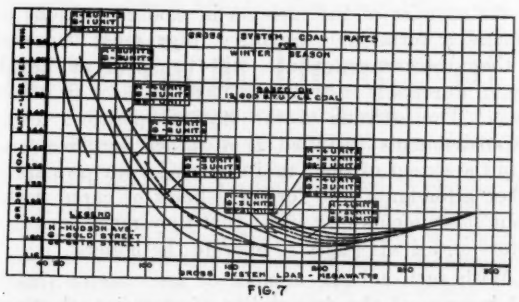


FIG. 7

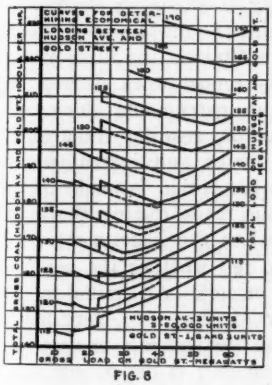


FIG. 8

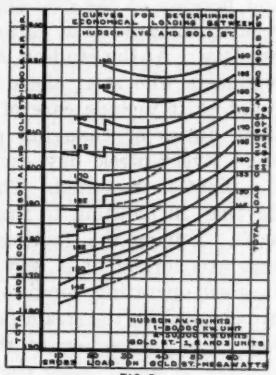


FIG 9

FIG. 7. GROSS SYSTEM COAL RATES FOR WINTER SEASON
FIGS. 8 AND 9. CURVES FOR DETERMINING LOADING BETWEEN HUDSON AVE. AND GOLD ST. STATIONS

In using these curves to predict the economy of operation for the coming year, it is necessary, however, to estimate the future load demand and output. Semi-logarithmic curves for yearly and monthly system maximum loads and output are therefore drawn up. Figure 10 shows yearly system and 60 cycle output. Representative load curves for each month were then drawn up to show the expected character of the load throughout the year.

From the load forecast and the curve showing proper station load distribution, the daily load curves for each month were obtained. Figure 11 illustrates the station load curve for July, 1927.

With the station load curve and load forecast and a load capacity chart (not shown) which is prepared, the number of boilers for each station for each month can be determined. Knowing the load curve and the number of boilers to be operated, the banked coal can be calculated. For each average week day and for each month the total coal rate and kw-hr. output for each station and the system can then be figured. Summing up these data for twelve months gives the estimated results of the year's consumption from which the operating costs can also be estimated.

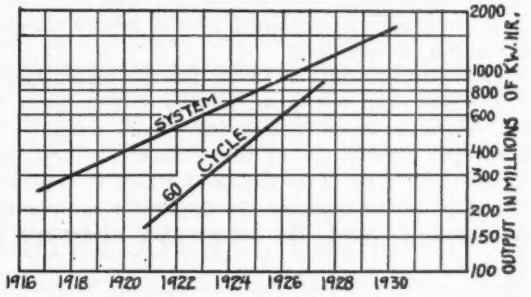


FIG. 10. SYSTEM AND 60-CYCLE TOTAL YEARLY OUTPUT

This method of preparing data ahead for a full year's operation gives all the information necessary for daily scheduling the machines and loading for the following day's operation. The curves are utilized in the same way as mentioned in connection with the average week day load curve discussion. The report not only provides the necessary information for the most economical operation but also supplies a target to aim at and a means of carefully checking and grading the actual operation throughout the year. In applying this method one thing should be kept in mind: if anything should happen to any piece of equipment, performance would be below what it should be. If any such contingency should actually occur, operation in strict accordance with any predetermined schedule would obviously not produce best efficiency. It is therefore necessary to know, not only what performance may be expected of any piece of apparatus, but what its actual performance is at all times.

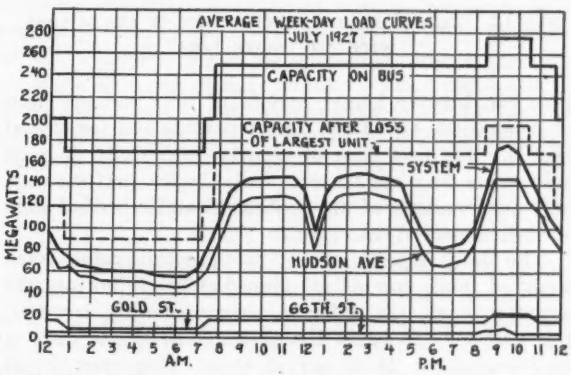


FIG. 11. AVERAGE WEEK DAY LOAD CURVES, JULY, 1927

To determine the actual performance at all times, tests are made at intervals and daily, weekly and monthly operating records are continually studied and compared.

As the performance of the station so intimately depends upon the performance of the prime movers, very complete tests throughout the range are made on new turbo-generator units. Performance tests are made also on new boilers throughout their range in order to establish a perfect operating standard towards which we must always work. This same idea is followed throughout all plants and is carried out even down to the auxiliary apparatus; in other words, wherever saving in operation may be obtained by the proper selection and loading of equipment.

With complete data available for the predetermination of economical operation, reports or records of the actual operation become increasingly more valuable. In general the reports are of two classes, the first class includes daily reports by means of which it is possible continually to tell whether the apparatus is operating satisfactorily or not. The second class of reports are

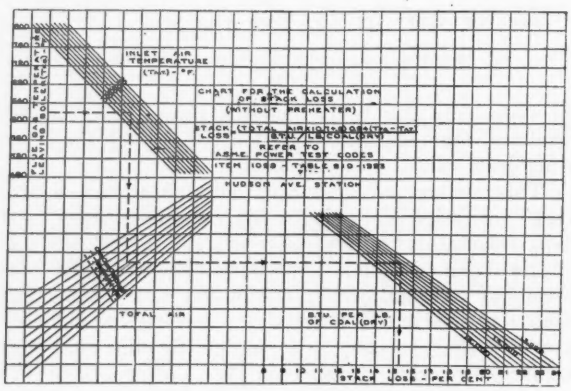


FIG. 12. CHART FOR THE CALCULATION OF STACK LOSS (WITHOUT PREHEATER)

those which cover longer periods of time and are used for comparison over these longer periods and for official records. The first class of reports cover daily data on main units and condensers, daily boiler performance, daily performance of air preheaters and classified data on station performance.

The daily reports are of the greatest value when prepared and completed immediately following the period covered. In order to accomplish this, however, it is necessary to begin the preparation of the data at the moment the 24-hr. period ends. Consequently, at midnight, three junior engineers start on this work which includes changing of recording charts, reading of recording integrators and the averaging of data. These men must also collect the daily coal samples and quarter them down in preparation for analysis. In this way all the data are prepared between midnight and 9 a.m. for the day force. The final calculations are completed by the day force and all these reports are finished and ready before noon of the day following that for which the report is made. In order to expedite this work as much as possible and to prevent errors, curves and charts are used to a great extent in the making of calculations. A sample of the labor saving charts used is shown in Fig. 12.

Assembly of the records is absolutely worthless, however, unless supplemented by intelligent thought, study and the use of the information contained. Quite often helpful and beneficial facts will be hidden away and will require digging before they are uncovered. Discussion of the performance records of the previous day at daily meetings is one of four ways in which the operating force obtains information regarding the functioning of the station and apparatus. The other three ways are through contact with the test men in the station, dissemination of station performance data in instruction classes of the company school and daily posting of charts and cards containing vital performance data.

Accurate Instruments Are Necessary

In the successful application of a system of this kind it is absolutely necessary to have accurate instruments. As the number of instruments in modern stations soon becomes a formidable quantity, they must be reliable so that their maintenance will be small as possible. Cheap, unreliable instruments have no place in a power plant. The attitude of the station operators towards the instruments installed is a rather significant sign as to the extent of their usefulness. In our own station, stoker attendants who formerly knew or cared nothing about instruments now insist that they must have boiler meters and draft gages to operate the boilers.

With such a large number of instruments installed and because of the desirability of changing charts and reading integrators at midnight, the night crew becomes essential. At the Hudson Ave. Station, the three junior engineers who start the daily report work during the night shift include care of the instruments along with their duties of changing records, reading integrators, etc. Every week day each meter and instrument in the plant is inspected. This inspection is made in the daytime in addition to the one made during the night shift. During the daytime when the instrument readings are normal, it is easy to tell whether the meter is in good operating condition or not. All boiler meters are checked on the steam flow, air flow zero every morning. The calibration of these instruments is very important as good boiler performance is dependent upon maintaining the correct steam-flow-air-flow relation. Most defects are easily discovered in the daily inspection. If they are overlooked or any obvious defects develop between inspections, the stoker attendant quickly notices and reports it. If, for some reason, action is not promptly taken, he immediately makes it known to the person responsible.

On account of the change in calibration due to the accumulation of soot and slag on heating surfaces, a weekly check is made on the steam-flow-air-flow relation at the high rating. This check is made in the following manner. First, the steam hand is checked on zero. The air flow lines are disconnected and the air flow balance checked. With ideal furnace and ash pit conditions, five flue gas samples, each taken over a ten-minute period, are analyzed by an Orsat. The radius is reset if necessary and with pens together another Orsat check is made. The steam flow card of the meters on the individual boilers is checked by the evaporation of each boiler. This figure is computed daily, using the lorry coal weight for each boiler and the figure is compared to the normal value. When meter shows evaporation above or below normal, the meter is carefully inspected, set on zero and lines blown down. If no change is

shown on the following day, the meter is opened up and cleaned, the mercury filtered, the level checked and the meter put back into service. The meters are also checked daily as a group by the following method. The total steam metered on all boilers is used to compute the station steam rate. Values from the venturi meters on the main unit condensate, heater condensate, and estimated auxiliary exhaust are totaled and compared with the steam rate previously figured. These two values usually check within one per cent.

In conclusion, the fact cannot be over emphasized that lowest overall system economy should be striven for and not merely the performance of a single station. To obtain the best results with the equipment at hand, knowledge of performance throughout its entire range is essential. Testing supplies this information and it must be continuous so that the latest conditions will always be available. The arrangement of the known data of the equipment for a considerable period ahead provides means of properly scheduling the turbines, boilers and auxiliaries to obtain the best results under the different load conditions. The arrangement of test and operating data in the proper form will provide the goal to strive towards in the operation of the system, station, machines, boilers and auxiliaries. The means of preparing of the schedules are furnished with the indicating equipment and the veracity of the report depends upon the recording instrument. Reliable and tried instruments are, therefore, the only ones worthy of consideration and systematized care, maintenance and checks keep them tuned up for their important function.

Economical Design of Natural Draft Chimneys

DESIGN METHODS WHICH, TAKING INTO ACCOUNT ALL OPERATING CONDITIONS, WILL RESULT IN THE MOST ECONOMICAL COMBINATION OF CHIMNEY HEIGHT AND DIAMETER. BY J. G. MINGLE

IN A BOILER PLANT the chimney is one of the most important parts of the entire installation, yet nothing in present day engineering practice is designed in a more haphazard and careless manner. Many which have been built in the past have been determined with the aid of a table of chimney sizes and boiler horsepowers, with no further attempt made to investigate the performance to determine whether the height is sufficient to create the draft necessary to overcome all of the various resistances or whether the area was sufficient properly and quickly to remove and dispose of gases from the furnace.

Due to this chaotic state, many plants have been erected with chimneys either too small, too large or badly proportioned and many operating troubles could have been obviated by the aid of a little plain thinking and sound common sense in regard to design. While the word "tall" may be a relative term, yet tall chimneys have been, are now, and always will be built, and the writer who stated that, "Tall chimneys are monuments to the folly of their builders" wrote not from knowledge but prejudice and ignorance. They are not monuments of folly, but useful structur designed for a specific purpose and a useful end.

Chimneys may be classified in two general types, natural draft chimneys and venturi chimneys, according to the manner in which they assist in the creation of draft. A natural draft chimney creates draft by means of an aspiration, while a venturi chimney creates draft by means of induction.

CHIMNEY HAS TWO SPECIFIC DUTIES

In connection with a steam producing plant, a natural draft chimney is required to assist in creation of the draft and to carry away the gases to a height where they will become least objectionable. There is a definite and direct relation between the chimney and the furnace, and the rate of disposal must be at least as great as the rate of generation. The latter statement should be constantly kept in mind, as it forms the starting point of all chimney design.

Speaking in general terms, the height of a properly designed chimney is dependent upon the amount of draft required to overcome the various resistances to the flow of the gases throughout the entire boiler plant installation, including the chimney, the temperature difference between the gases and the atmosphere, the area, the amount of gases generated and passing through the installation and upon the temperature and velocity of the gases. The atmospheric pressure and density of the gases affect the size to relatively small extent.

Of all the necessary operating factors to determine the size of the chimney, that of the velocity of the chimney gases is the only one whose value cannot be either computed or assumed to a relatively close degree of accuracy, although to arrive at some definite size, it is necessary to assume an arbitrary value, and the number of values which may be selected is, from a theoretical standpoint, practically infinite. The problem to be solved, therefore, is of deducing an equation for the most economical velocity or that velocity which will result in the cheapest chimney structure.

CHIMNEY HEIGHT SHOULD BE MEASURED FROM GRATE ELEVATION

Both draft and capacity performance must be investigated in order to determine the proper height and area, the required height of a natural draft chimney being that part of the structure measured between the grate line elevation and the top of the chimney. The actual height may be more or less than the required height, depending upon whether the grate line elevation is above the ground line elevation, or whether the chimney is built on top of the boiler house. The required height is sometimes erroneously measured from the horizontal center line of the breeching opening. All vertical parts of the boiler, uptake and breechings are, in effect, a part of the chimney, the only difference being that the gas is flowing vertically upward in them instead of in the chimney itself.

Natural draft is a difference of head between the relatively hot gases in the chimney, and an equivalent amount of colder outside air or atmosphere. It is customary to express the pressure difference in terms of draft measured in inches of water.

When the gases are flowing freely in the chimney,

the theoretical intensity, or draft is decreased by two major losses; loss of draft due to velocity, and loss of draft due to friction. The former is expressed or varies as the square of the velocity, and the second is determined from Fanning's equation of frictional resistance. The difference between this theoretical draft and the losses is the available draft which must be balanced or equal to the sum of various losses of draft throughout the installation and known as the required draft, made up of the draft losses through the fuel bed, the boiler, the breechings, the economizer or air preheater and the losses due to turns, bends and sudden enlargement of a section.

Equation 5 gives the required height of the chimney with all the operating factors taken into consideration.

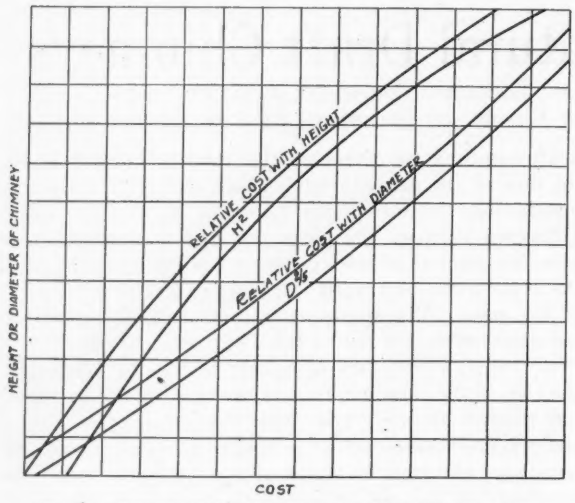


FIG. 1. COST IS INFLUENCED BY BOTH HEIGHT AND DIAMETER

and values of the various constants used for convenience given in Equations 1, 2 and 3. For a chimney with a circular section, Equation 5 reduces to Equation 5A.

Gas Capacity Depends Upon the Diameter

In developing an equation for the area or diameter of a chimney, it is necessary to investigate its capacity, or its ability to discharge gases. Equation 6 gives the capacity of an operating chimney in pounds of gas flowing per second under the existing operating conditions. Most chimneys are built circular in shape, and their size is expressed in terms of height and diameter, so that simplifying Equation 6 the diameter of a circular chimney can be expressed by Equation 6A.

From these equations it will be seen that the size of the chimney is affected by temperature of the atmosphere, the temperature of the chimney gases, density of the chimney gases, density of the atmosphere, atmospheric pressure, altitude, coefficient of friction or degrees of roughness of the inside surface, quantity of gases flowing, required draft and velocity of the chimney gases. All of the above factors, with the exception of velocity can be either observed or computed to a fair degree of accuracy. In the case of a new chimney or new installation the value of some of the factors is known definitely, but the value of others must be assumed to a certain extent. In the case of a new chimney for an existing installation, the values of all of the factors may be ascertained accurately.

In either case, in order to arrive at some definite size for the new chimney, it is necessary to reach some arbitrary value for the velocity of the chimney gases, as is the case with other factors. There is no guide which may be used in selecting a value for this. Insofar as equations are concerned, it is impossible to tell whether this figure should be 5 or 500 ft. per sec. Even if tests are available for operating chimneys, there is no evidence at hand that proves that the velocity as observed in the operating chimney of similar size to the one to be erected is the proper one to use.

Cost Determines the Most Economical Velocity

Any value of velocity, reasonably assumed, will result in a size to answer the purpose and fulfill all requirements, provided all the other factors have been taken into consideration. In order to limit the range of choice, it is necessary to establish some method or criterion as to the cost of the chimney. It is quite

TABLE I. EQUATIONS USED TO DETERMINE THE MOST ECONOMICAL CHIMNEY

$$K_a = 0.049\,\frac{W_c B_o}{T_c} \quad (1)$$

$$K_b = 3.16\,B_o\left(\frac{W_o}{T_o} - \frac{W_c}{T_c}\right) \quad (2)$$

$$K_c = 0.049\,\frac{f W_c B_o}{T_c} \quad (3)$$

$$K_d = 0.278\,\frac{W T_c}{B_o W_c} \quad (4)$$

$$H = \frac{D_r + K_a V^2}{K_b - \frac{K_c V^2}{C_d}} \quad (5)$$

FOR A CHIMNEY WITH A CIRCULAR SECTION

$$H = \frac{D_r + K_a V^2}{K_b - \frac{4 K_c V^2}{D}} \quad (5a)$$

$$W = 16.43\,\frac{A V B_o W_c}{T_c} \quad (6)$$

FOR A CHIMNEY WITH A CIRCULAR SECTION

$$D = K_d\sqrt{\frac{I}{V}} \quad (6a)$$

$$V_e = \sqrt{\frac{D_r K_b K_d}{24\,D_r K_c V^{\frac{1}{2}} + 3 K_a K_b K_d}} \quad (7)$$

IF $V^{\frac{1}{2}}$ IS ASSUMED TO EQUAL 5.5

$$V_e = \sqrt{\frac{D_r K_b K_d}{132\,D_r K_c + 3 K_a K_b K_d}} \quad (7a)$$

WHERE

- A = AREA OF CHIMNEY IN SQ. FT.
- B_o = OBSERVED ATMOSPHERIC PRESSURE IN INCHES OF MERCURY
- B = SEA LEVEL ATMOSPHERIC PRESSURE, ASSUMED 29.92 IN. OF MERCURY
- C_d = HYDRAULIC RADIUS IN FT.
- D = DIAMETER OF CHIMNEY IN FT.
- D_r = REQUIRED DRAFT IN INCHES OF WATER
- f = COEFFICIENT OF FRICTION (FANNING'S EQ)
- H = HEIGHT OF CHIMNEY ABOVE GRATE BARS IN FT.
- T_o = ABSOLUTE TEMPERATURE OF ATMOSPHERE IN DEG. F.
- T_c = ABSOLUTE TEMPERATURE OF CHIMNEY GASES IN DEG.F.
- V = VELOCITY OF CHIMNEY GASES IN FT. PER SECOND
- V_e = MOST ECONOMICAL VELOCITY IN FT. PER SECOND
- W_o = WEIGHT OF ATMOSPHERE PER CU.FT. AT TEMP. T (ASSUMED 32 DEG.F.)
- W_c = WEIGHT OF CHIMNEY GASES PER CU.FT. AT TEMP. T (ASSUMED 32 DEG.F.)
- W = POUNDS OF CHIMNEY GAS FLOWING PER SECOND

obvious that, all factors being equal, and speaking in relative terms, a short chimney will cost less than a tall one, and one with a small diameter will cost less than one with a large diameter.

The cost of the chimney should be based, among other less important but by no means insignificant factors, on the volume of the material, or its equivalent, regardless of whether the chimney is built of steel, brick or concrete. It is quite apparent that, all other things being equal, the more volume of material used in construction, the greater will be the cost.

Actual designs show that the volume of material in a chimney varies practically as the square of the height, and as the 2/5 power of the diameter. These values plotted in Fig. 1, are based on the assumption that various sizes are designed for the same structural con-

ditions, of wind pressure, unit weight, kind of material used and are limited to the same stress values of tension and compression. Many factors enter into and affect the cost of the chimney, but for practical purposes the relations expressed above may be assumed to hold true, and will be assumed to be rigidly true.

Cheapest Structure Is a Compromise Between Height and Diameter

A comparatively low velocity will insure a relatively cheap structure, insofar as the height is concerned, while a comparatively high velocity will insure a relatively cheap structure as far as diameter is concerned. It is therefore necessary to find such a velocity as will strike an average and give a structure whose height will be not too great nor whose diameter too small, but at the same time result in a relatively cheap construction, in other words a combination height and diameter whose cost will be less than that for any other combination of height and diameter determined by any other velocity.

On this basis, the most economical value of the velocity is given in Equation 7, an examination of which will disclose the fact that the factor V appears

TABLE II. APPLICATION OF EQUATIONS TO A SET OF TYPICAL OPERATING CONDITIONS

OPERATING CONDITIONS

MEAN ATMOSPHERIC TEMPERATURE 60 DEG. F.
MEAN CHIMNEY GAS TEMPERATURE 500 DEG. F.
DENSITY OF CHIMNEY GASES AT 32 DEG. F. 0.084 LB. PER CU. FT.
ATMOSPHERIC PRESSURE 29.92 IN. OF MERCURY
COEFFICIENT OF FRICTION 0.016
QUANTITY OF GASES GENERATED AND FLOWING 100 LB. PER SECOND
REQUIRED DRAFT 1.4 IN. OF WATER

ECONOMICAL VELOCITY

FROM EQ. 1: $K_a = 0.049 \frac{0.084 \times 29.92}{960} = 0.000128$

FROM EQ. 2: $K_b = 33.16 \times 29.92 \left(\frac{0.0807}{520} - \frac{0.084}{960}\right) = 0.00638$

FROM EQ. 3: $K_c = 0.049 \frac{0.084 \times 29.92 \times 0.016}{960} = 0.00000205$

FROM EQ. 4: $K_d = 0.278 \sqrt{\frac{100 \times 960}{0.084 \times 29.92}} = 54.4$

SUBSTITUTING THESE QUANTITIES IN EQ. 7a:

$$V_e = \sqrt{\frac{1.4 \times 0.00638 \times 54.4}{132 \times 1.4 \times 0.00000205 + 3 \times 0.000128 \times 0.00638 \times 54.4}} = 30.8$$

DIAMETER

FROM EQ. 4 AND 6a: $D = 54.4 \sqrt{\frac{1}{30.8}} = 9.8'$

HEIGHT

FROM EQ. 1, 2, 3 AND 5a:

$$H = \frac{1.4 + 0.000128 \times (30.8)^2}{0.00638 - \frac{4 \times 0.00000205 \times (30.8)^2}{9.8}} = 272'$$

on both sides of the equation. It has been found by experience that the economical velocity in average operating conditions is in the neighborhood of 30 ft. per sec., and a close approximation may be obtained by assuming a value of V = 30, which when substituted in Equation 7 gives Equation 7A, or the economical velocity of the chimney in the simplest form, based on the existent or assumed operating conditions.

To show the application of the equation, an example has been worked out in Table II for the following conditions:

Mean atmospheric temperature, 60 deg. F.

Mean chimney gas temperature, 500 deg. F.

Density of chimney gases at 33 deg. F., 0.084 lb. per cu. ft.

Atmospheric pressure, 29.92 in mercury.

Coefficient of friction, 0.016.

Amount of gases generated and flowing, 100 lb. per sec., required draft, 1.4 in. of water.

Substituting the correct values in Equations 1, 2, 3 and 4 and substituting the calculated values in Equation 7A, gives the most economical velocity as 30.8 ft. per sec.

After this has been determined, it is a relatively easy matter to determine the required size by substituting the values for the various constants, which have already been calculated in determining the velocity, in Equations 5A and 6A. In determining the required size, it is necessary to calculate the diameter first insomuch as the diameter is a factor in the equation for the height. From Equations 5A and 6A the diameter is found equal to 9.8 ft., and from Equations 1, 2, 3 and 5A the required height 272 ft.

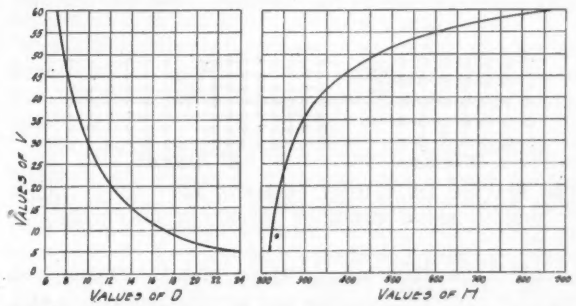


FIG. 2. SHOWING THE EFFECT OF VELOCITY ON THE HEIGHT AND DIAMETER OF THE CHIMNEY

At first sight Equation 7A appears to be extremely cumbersome to use. When, however, the values of the various constants have been determined and substituted in the equation the solution becomes relatively simple. The example itself will serve as an excellent guide in reducing the substituted quantities. For average working conditions, the number of ciphers between the decimal point and the first significant figure of each factor will remain practically as noted.

Operating Conditions Can Be Satisfied by Infinite Numbers of Combinations

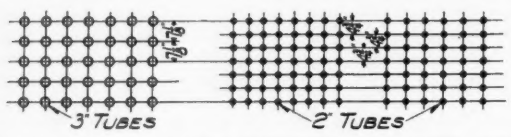
As the assumed gas velocity is increased, the diameter of the chimney decreases, the height increases. Using the example given as a set of typical operating conditions, the corresponding diameter and height for various velocities are shown graphically in Fig. 2. This shows in a vivid manner how the velocity affects the size of the chimney. Each one of the combinations shown will answer the purpose. That is to say, each size will be of sufficient height to create a draft of 1.4 in. of water and of sufficient diameter to discharge the gases at the rate of 100 lb. per sec., but the combination above will give the cheapest structure. If for one reason or another it is necessary to maintain a height greater than 272 ft. as for example, 331 ft., then the diameter need only be 8.6 ft. instead of 9.8. It is obvious, however, that this size will be considerably more costly than the more economical size noted.

The advantage of determining the size of a chimney by this method lies in the fact that all the operating

factors which affect the performance are taken into account. If the operating factors are known, or have been reasonably assumed, and the calculations have been accurately performed, then the proper size will be obtained and the chimney will function properly and in accordance with the operating factors. Insofar as the chimney is concerned, there will be no plant operating troubles with which to contend. While the collecting of all the required data may be somewhat tedious, the information demanded is no more in detail than that required for the designing of the plant itself.

Modern Methods Influence Boiler Tube Size

IN A RECENT ISSUE of the Safety Valve, the New Heine VX boiler, a new bent tube type, designed for pressures in excess of 325 lb. gage, is described with particular reference to the increased tube spacing and



TUBE SPACING IN A HIGH PRESSURE BENT TUBE BOILER DESIGN, USING TUBES OF DIFFERENT DIAMETERS

reduced tube diameters. Details and illustrations of units for various conditions and services, both with and without economizers, are followed by a short discussion of boiler tubes and tube sizes.

Perhaps a natural question is why did the earlier boiler designs utilize large diameter tubes? There are probably a number of good reasons. Earlier designs came out during the welded tube era when the tube manufacturers found it easier to weld the larger diameter tubes. Because their rejections were much lower, they favored the large tubes while from the operator's standpoint the larger tubes were to be preferred because a larger tool could be used for cleaning, an item of much importance when air, water and steam driven tube cleaners were not in general use.

Other operators considered large diameter tubes better because they could run their boilers longer before it was necessary to clean them or before they were entirely clogged up with scale, not an infrequent occurrence before the days of water treatment, surface condensers and feed water evaporators.

Water Treating Systems Influence the Diameters

Present day high pressure plants have water treating systems if the water requires it, or a system of multiple effect evaporators furnishes distilled water for the boiler feed so that scale is entirely eliminated. If scale forms there are many excellent makes of turbine tube cleaners which will quickly and efficiently remove it. All former objections to small diameter tubes have now been removed by seamless tubes, modern methods and apparatus.

Why not use 2-in. tubes throughout? The boiler would not be as efficient with 2-in. tubes in the front bank. The front bank of tubes of any boiler absorbs radiant heat so that the more tube surface that can be seen from any point in the furnace, the greater its radiant heat absorbing ability. Therefore, 3-in. tubes in the front bank on 7⅛-in. centers are far more efficient than a bank of 2-in. diameter tubes on the 4¾-in. centers. All parts of the furnace can see far into the bank and in case a superheater is placed there, it receives a greater portion of radiant heat than would be possible in a closely packed 2-in. tube bank.

Second Bank Tubes Depend upon Heat Transfer by Convection

Efficiency of heat absorbing surfaces in the second and third tube banks depends entirely upon heat transfer by convection. The small gas streams due to the closely nested 2-in. tubes insure intimate contact between hot gases and tube surface. The hot center of core of the parallel gas streams is entirely eliminated. The large number of small tubes also allows of a more exact proportional division among the tube banks to obtain the proper gas passage area cross section.

Eliminating Thrust and Leakage in Centrifugal Pumps

Adjustable Wearing Rings and Thrust Bearings Are Needed to Keep Up Best Efficiency. By J. J. Conway

FOR RELIABLE operation and long life, two real problems to be overcome in the design of centrifugal pumps are the wearing or sealing rings and the thrust. When new, a pump has its maximum efficiency but as soon as it is operated the wearing rings start to wear and leakage begins between the high-pressure passage ways and the low-pressure passages. This means, at first, only a slight loss in efficiency but, as the wear increases, the leakage becomes greater and the efficiency less. When this decrease in efficiency becomes appreciable, the rings should be renewed, thus bringing the pump to maximum efficiency again.

Properties of the liquid to be handled determine, to a great extent, the wear on the rings. If the liquid is clear water, the rings will wear but slowly but, if the water is gritty or other similar substance is pumped, the wear may be alarming. In such cases, it is usually better to install a pump with open impeller, having no wearing rings, and accept the lower efficiency due to the open impeller and greater clearances.

Two types of wearing rings, the flat and the labyrinth types, are in common use. Personally, I believe that the flat ring gives more value for the money expended, as it costs less than the labyrinth and wears about as long. It is a known fact that, with the labyrinth type, the corners round off in a short time, leaving large passages through the labyrinth turns.

Gain from Adjustable Wearing Rings

Recently, one manufacturer has perfected and patented an adjustable wearing ring which can be taken up every few months so that the pump is brought back to maximum efficiency. The device looks fool proof and serviceable. For a 12-in. pump, handling 5000 g.p.m. against 115 ft. head at 79 per cent efficiency and running 24 hr. a day, it will require about 184 hp. for driving. It is severe service and, in all probability the

wearing rings will have to be renewed at the end of a year, when it is safe to say that the efficiency will be not over 72 per cent, or an average of 75.5 per cent for the year. The average capacity of the pump for the year would be 4770 g.p.m. so that, if 5000 g.p.m. were required, 230 g.p.m. would have to be taken from some other pump on the average. This amount at 115 ft. head and 75.5 per cent efficiency means a loss of about 8.48 hp., or for the year a loss of 74,100 hp-hr. If this pump had adjustable wearing rings, which were adjusted every 3 mo., the efficiency would have dropped to say only 77 per cent at any time and the average for the year would have been 78 per cent. This, worked out as before, gives a loss of 19,700 hp-hr. as against 74,100 hp-hr. for the non-adjustable rings, a saving of 54,400 hp-hr. a year.

At first, I thought of the adjustable ring as of doubtful value, with something of a complicated job in the adjusting, which the plant operator might have trouble in doing properly but, after investigating, I found it to be a simple matter of turning the ring up on a thread until the desired clearance is obtained, then locking it in place with special set screws. The top half of the casing is replaced and the pump is ready to operate.

Hydraulic Thrust Should Be Balanced

In a series of tests run at the manufacturer's plant, a standard pump was run for several days at a time and the adjustable rings automatically took care of any unbalanced thrust that arose. It has, therefore, some hydraulic balancing effect but it is understood that pumps equipped with these rings all have an additional thrust bearing as a safeguard. The balancing effect is mentioned as a matter of interest.

On small pumps, requiring but little power for driving, it might be considered a waste of money to provide adjustable wearing rings as they are naturally more expensive than standard rings. But when wear becomes noticeable, the operator can take up the rings and not have the trouble of replacing them, so that the saving in labor will be worth the extra expense of equipment, even for small pumps.

Unbalanced thrust in a centrifugal pump is probably the chief reason for trouble. For a pump properly installed, unbalanced thrust comes from a greater pressure on one side of the impeller than on the other. With single suction, this is expected and compensated in some manner such as a marine type or ball thrust bearing or a hydraulic balancing device. With the double suction, there is theoretically no thrust, as the same amount of liquid is supposed to enter each side of the impeller. Just how anybody can be sure that equal amounts do so enter, I do not know, for there is certainly nothing inside the pump to direct a certain amount one way and a certain amount the other. The liquid would have to pass into the suction opening of the casing running full and without any swirl. Each passage would have to be the same size which is hard to accomplish. Any other conditions would result in more liquid on one side of the impeller than the other with a resulting end thrust. Most pump makers provide a good thrust bearing, although a few still use a single pinned collar as a thrust device. On a small pump a single collar may be sufficient but it certainly should be fastened in a more substantial manner than by a single pin.

I would use a single suction impeller multi-stage pump with the thrust taken care of by a hydraulic balancing disc or drum but I would also equip this pump with a good marine or ball type thrust bearing. I would not rely entirely on a hydraulic balancing device, whether divided over a number of double suction impellers or a single drum when using single suction impellers. One advantage of the single suction impeller is that the number of wearing or sealing rings is halved from that needed with double suction. Also, with double suction impellers, it is necessary to seal along the shaft between the stages because the pressures are higher on the suction side of each succeeding stage and, as the suction openings are almost beside one another, a good seal is needed. As this running seal wears, there is, in time, a considerable leakage from the higher pressure suction to the lower pressure suction which, with twice the number of sealing rings, seems to give the double-suction impeller multi-stage pump three times the leakage that the single-suction multi-stage would have.

This is all to prove that, however well a pump is hydraulically balanced, it should have a good positive thrust bearing. The marine type, ball type and roller type have all proved successful and I believe that, except possibly for very high speeds and pressures, there is no need for high-priced special thrust bearings on centrifugal pumps.

Ice Manufacturers Report Increase in Production

ACCORDING TO data collected at the Biennial Census of manufacturers taken in 1926 by the Department of Commerce, the establishments engaged primarily in the manufacture of ice reported for 1925 products valued at $186,969,000, an increase of 15½ per cent, as compared with $164,662, for 1923, the last preceding census year.

The total for 1925 was made up as follows:

Pan ice, 38,669,000 t. valued at	$178,157,000
Plate ice, 585,000 t.	2,625,000
Receipts from cold storage refrigeration	4,180,000
Miscellaneous products, chiefly beverages and ice cream	1,700,000

In addition, ice was manufactured to some extent as a subsidiary product by establishments engaged primarily in other industries. The value of the ice thus produced outside the industry proper in 1923 was $5,930,000 an amount equal to 3.6 per cent of the total value of products reported for the ice manufacturing industry. The corresponding value for 1925 has not yet been calculated, but will be shown in the final report of the present census. Of the 3077 establishments reporting for 1925, 233 were located in Texas, 223 in Pennsylvania, 188 in Illinois, 168 in California, 156 in Ohio, 151 in New York, 132 in Missouri, 121 in Kansas, 107 in Indiana, 105 in Oklahoma, 104 in Virginia, 102 in Florida, and the remaining 1287 were distributed through 35 other states and the District of Columbia.

Volume Control for Compressor Economy

POPULARITY OF THE MOTOR-DRIVEN COMPRESSOR DUE LARGELY TO THE SUCCESSFUL APPLICATION OF MECHANICAL CONTROL SYSTEMS

VOLUME control methods, like automatic plate valves, are largely the result of insistent demands for direct-motor-driven air compressor units. Electrical complications practically prohibit the use of variable speed motors for this service, making mechanical

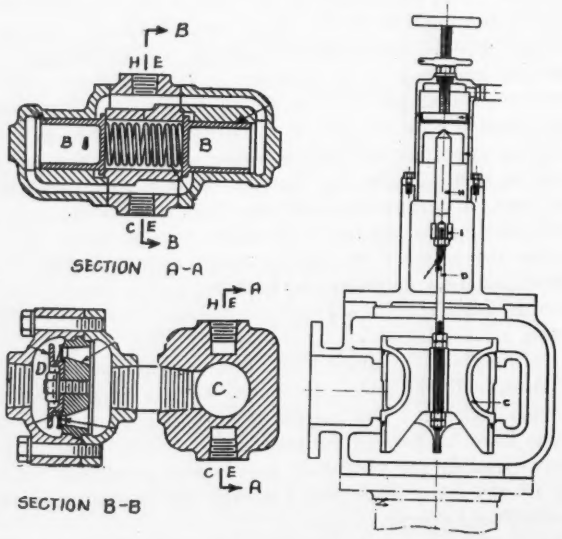


FIG. 1. THE HIGH-PRESSURE RELIEF (LEFT) OPERATES AUTOMATICALLY A FEW REVOLUTIONS AFTER THE SUCTION UNLOADER (RIGHT) CLOSES

methods of volume regulation necessary. As the demand for air may vary from zero to 100 per cent of the rated capacity of the machine, the system used must be flexible enough to meet the conditions of operation and sensitive enough to operate on a small change in receiver pressure.

Quite naturally, various manufacturers, influenced by machine construction, valve design and operating conditions proceeded along different lines in the solution of the same problem. The light automatic plate valve in its many variations proved readily adaptable resulting in many commercially successful methods which, for the sake of convenience, may be roughly grouped into three classes: 1. Total closure regulator; 2. Clearance pockets; 3. Inlet valve held open for entire stroke or part stroke.

Originally the total closure regulator was in universal use and still enjoys wide popularity especially on the smaller machines. Regulation is obtained by means of a valve in the suction line. As a rule, this valve is either wide open or tightly closed so that operation is limited to two points, zero and 100 per cent capacity. Throttling losses are eliminated, the machine always working on one of the two most efficient points of operation, no load or full load, the frequency of operation depending somewhat on the extent of the system, receiver capacity and pressure variation allowable.

More recent devices strive to load and unload the machine in a number of steps so that the difference between any two steps will be comparatively small. This may be accomplished by means of clearance pockets, arranged to be thrown, either manually or automatically in communication with the ends of the air cylinders. A portion of the air is compressed into the added clearance space instead of passing through the discharge valves. On the return stroke, this air re-expands, keeping the inlet valve from opening until the pressure in the cylinder drops to the intake pressure. Free air is then admitted to the cylinder, but the effective length of the stroke is reduced.

Theoretically, there is no reason why any number of pockets could not be used to obtain a very gradual loading and unloading. Construction difficulties, valve areas and jacket water cooling surface, however, set a practical limit so that a five-step control, i.e., 100, 75, 50, 25 and 0 per cent capacity, has been accepted as satisfactorily meeting both operating and construction demands. Compressors operating on fairly constant loads for long periods of time are often fitted with manually-operated clearance pockets. This practice is becoming popular on ammonia compressors where the pockets are usually arranged to give half capacity, to

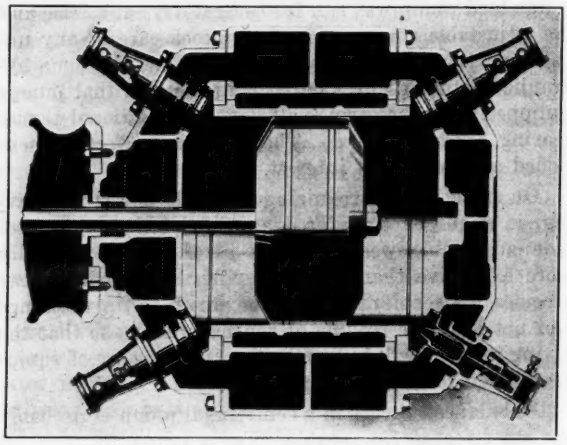


FIG. 2. CLEARANCE POCKETS ARE LOCATED SO AS NOT TO INTERFERE WITH THE WATER JACKET AROUND THE CYLINDER

cut down the power consumption during periods of low refrigerating loads when the full machine capacity is not required.

The third method, holding the inlet valves open, is probably the simplest construction and has been adopted by the majority of manufacturers. On large, long-stroke machines, the suction valves may be held open part of the stroke, giving an infinite number of operating steps and allowing the machine to meet any air demand within its rating. This is not possible on the smaller high-speed short-stroke machines where it is not practical to synchronize the valves and stroke. Each end must, therefore, be completely loaded or unloaded, hence this type of control is limited to 100, 50 and zero per cent capacity, known as "three-point" control.

With variations, a number of companies made use of this method for single and two-stage vertical and horizontal machines sometimes combining it with one or more clearance pockets to give an added number of steps.

High Pressure Relief Works with Low Pressure Valve to Eliminate Undesirable Conditions

For use on all its angle-compound type compressors, the Sullivan Machinery Co. has developed its Multi-Step control, consisting mainly of an unloading regulator valve on the intake cylinders and a high-pressure relief valve on the high-pressure cylinders. Cross sections of the low-pressure regulator and the high-pressure relief valve with details of construction are shown in Fig. 1. The low-pressure regulating valve, placed on the intake of the compressor, is connected to the air receiver and is so designed that, when the air pressure in the receiver has reached the desired limit, the valve automatically operates to shut off the supply of air to the compressor. When the demand for air begins once more, that is, when the pressure falls below the point at which the control device is set to act, the valve opens fully and the compressor automatically resumes its load until the demand for air again ceases.

Working independently of but in conjunction with the low pressure control, the high-pressure relief valve is automatically cut in, after the low-pressure control has been on a few revolutions and the high pressure cylinder has pumped out the intercooler. This valve, right hand side of Fig. 1, is connected to the clearance spaces of the cylinder as indicated. The partial vacuum in space B allows the spring-loaded valve to open, throwing the opposite end of the cylinder in communication with atmosphere through spaces C and D to allow the escape of the small amount of air leakage, which otherwise would be compressed to full discharge pressure. This part of the control eliminates the possibility of building up excessive temperatures and pressures at no load operation.

Any fractional load is taken care of automatically by this control and pilot valves are set to operate on pressure differentials as low as deemed necessary by the operator to accomplish the best result for each specific condition. When no air is required, the only power expenditure is that used in overcoming friction. Twin angle-compound units are built with separate pedestal bearing supporting the motor. Couplings are included between each unit and the motor so that, in case of a prolonged period where only one-half the compressor capacity is required, one-half of the unit may be disconnected from the motor.

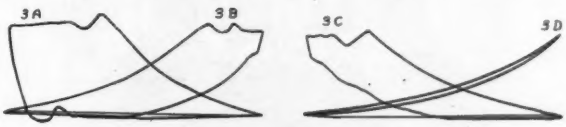


FIG. 3. INDICATOR CARDS SHOW THE ACTION OF CLEARANCE POCKETS ON COMPRESSOR CAPACITY

Clearance pockets are usually used by the Ingersoll-Rand Co., for capacity regulation, a cross section of one of its class PRE compressors, Fig. 2, showing the arrangement of the pockets clearly. Each cylinder has four pockets, two on either end of the cylinder and so proportioned that each one will reduce the capacity of that end 50 per cent. Indicator cards, Fig. 3, taken from the low-pressure side of a two-stage machine, show the action of this control at 75 and 25 per cent capacity. Card 3A shows a normal card given by both ends at full load while 3B shows the effect of one clearance pocket. In card 3C, one clearance pocket has been opened to reduce the capacity 50 per cent while the second pocket on the opposite end, 3D, has been opened up and the capacity of this end cut to zero.

Clearance pocket valves are operated by air from the receiver and controlled by an air-operated pilot valve or governor. From 1 to 2 lb. pressure difference is usually required between each two steps, although this

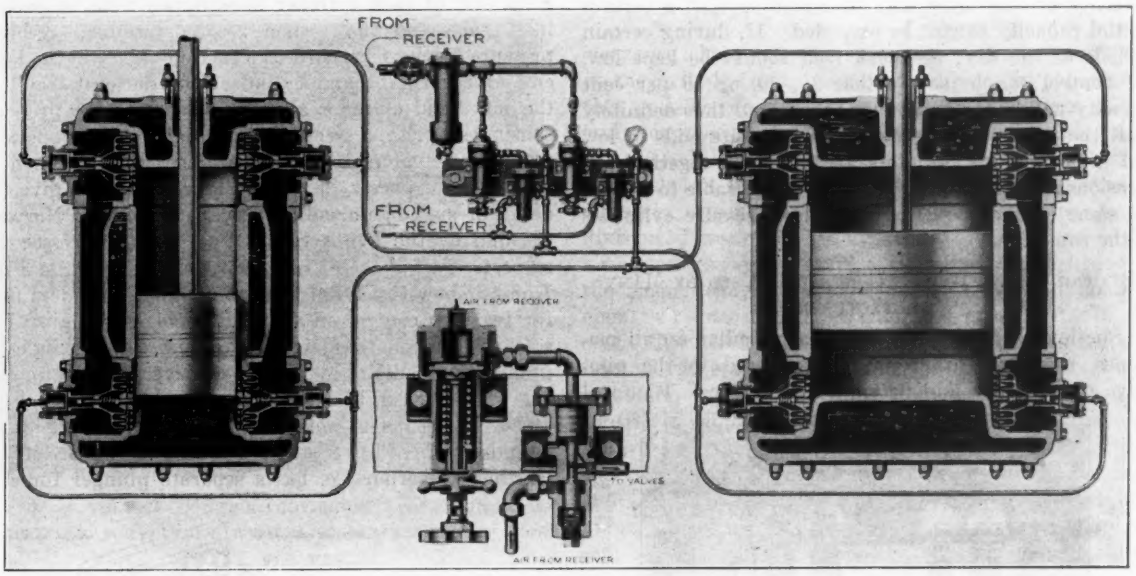


FIG. 4. SCHEMATIC DIAGRAM OF A THREE-STEP SUCTION VALVE BYPASS OPERATED BY TWO AIR PILOT VALVES

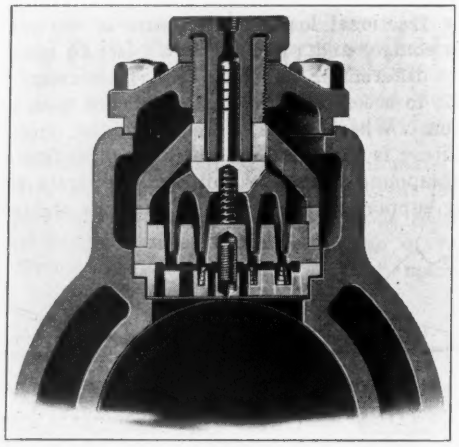


FIG. 5. SUCTION VALVES ARE KEPT FROM SEATING BY FINGERS IN THE BYPASS CONTROL SYSTEMS

can be reduced to as low as ¼ lb. if necessary to meet unusual conditions. Receiver pressure may be changed as desired by shifting weights on the lever arm of the governor or this lever may be locked so that a certain partial capacity cannot be exceeded. If, during certain periods of the day, the peak load should be kept low, the control can be set so that 25, 50, or 75 per cent capacity will be the maximum output and thus definitely limit the power peaks. As a rule, opposite ends of low and high-pressure cylinders are unloaded together but occasions sometimes arise where it is advisable to unload the same ends of both high and low-pressure cylinders at the same time.

Suction Valve Bypass Control Is Used by Many Manufacturers

Suction valve bypass controls are similar on all machines, the chief difference being found in the pilot valve or governor and details of the valves. Figure 4

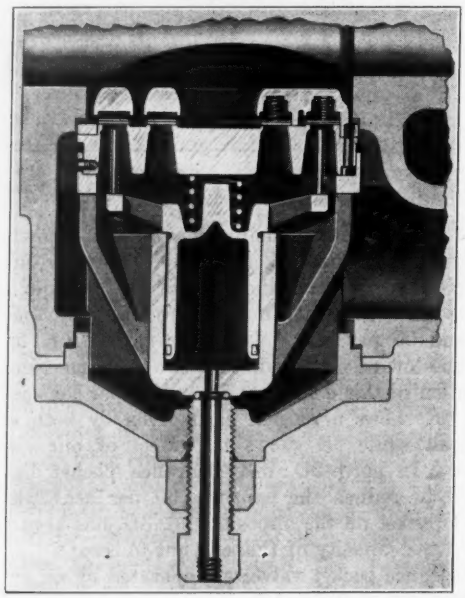


FIG. 6. LEVERS ENABLE A SINGLE AIR PLUNGER TO OPERATE TWO VALVES IN THIS VERTICAL MACHINE

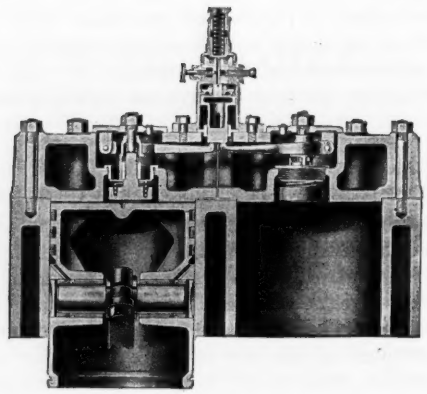


FIG. 7. VALVES FIT INTO THE CYLINDER WITH LITTLE EXCESS CLEARANCE VOLUME

is a schematic diagram of the system used by the Chicago Pneumatic Tool Co., on its two-stage and duplex single-stage machines. The cross section of the pilot valve shows the construction and method of operation. About 2 lb. pressure difference is used between steps. Each end of each cylinder is equipped with unloading inlet valves so that, when a predetermined receiver pressure has been reached, the suction valves in the head end of the right hand cylinder and the crank end of the left hand cylinder are held open. If the pressure continues to rise, a second differential unloader operates to hold the valves in the remaining two ends open to reduce the capacity to zero. Figures 5 and 6 give the detail of suction unloading valves used by the Norwalk Co. and by the Pennsylvania Pump & Compressor Co. respectively for their three-step unloaders, while Figs. 7 and 8 show two types of suction valve unloaders used for two-step control on vertical machines. Figure 7 is a Curtis Pneumatic Machine Co. unit with a single air plunger unloading, by means of lever, two cylinders. The unloader can be set for any variation of from ½ to 10 lb. by means of spring tension on the air plunger cylinder. In Fig. 8, the vertical compressor of the Gardner Governor Co. has a separate plunger for each

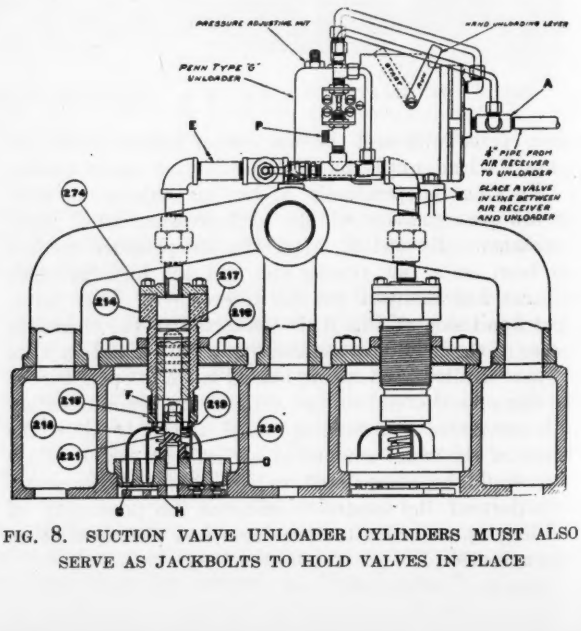


FIG. 8. SUCTION VALVE UNLOADER CYLINDERS MUST ALSO SERVE AS JACKBOLTS TO HOLD VALVES IN PLACE

cylinder, both plungers being operated by the diaphragm type pilot valve shown in the illustration.

Entire Valve Body Rotated by Air Pressure to Give Regulation

Construction features of the valve and compressor have an important bearing on the control and the Nordberg Mfg. Co. has developed the regulator shown in Fig. 9 attached to the low-pressure cylinder of a 28 and 50 by 36-in. compressor. Nordberg plate valves are fastened to a valve body and fitted into a port similar to a Corliss valve. By rotating the valve body, air will be bypassed back through the valve, giving the same effect as though it were held open. Cranks are set 180 deg. apart and high and low-pressure crank ends and the high and low-pressure head ends unload together. The first step unloads the head ends reducing the capacity 50 per cent, while the second step unloads the crank ends to cut the capacity to zero. Valves are rotated by an air-pressure pot and steadied by an oil dash pot. Cross sections of the pressure pot and the governor are shown in Fig. 10, drawn to the same scale. Air from the receiver is brought to A, B, and

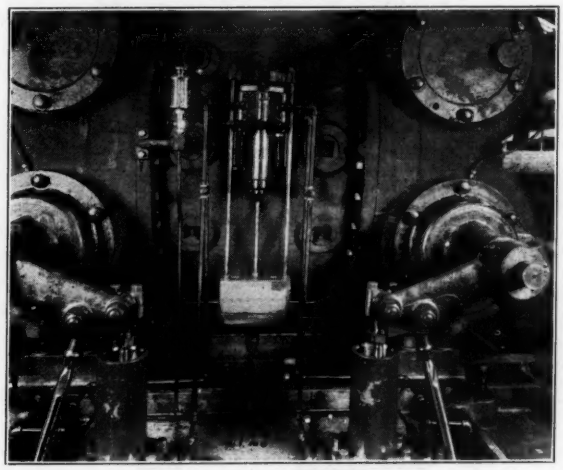


FIG. 9. A VOLUME CONTROL GOVERNOR REGULATING THE OUTPUT OF A CYLINDER WITH A DISPLACEMENT OF 9580 CU. FT. PER MIN.

C. Through A, pressure is transmitted to the bottom of plunger P by oil. As the receiver pressure increases, the plunger rises followed by the pilot valves V which uncover ports D admitting high-pressure air from C through D to E under the bottom of the air-pot plunger. When the pressure drops, the pilot valves fall and air is exhausted from the pressure pot through E and D to the atmosphere. By arranging pilot valve ports, the plungers are operated at different pressures, one before the other to give two steps. Variations in receiver pressure can be regulated by weights on the lower part of the governor, by a coil spring in the same location or by regulation of the oil dash pot.

Clearance pockets and suction valve bypass control are sometimes combined and, by using one clearance pocket, the Worthington Pump & Machinery Corp. has developed the Laidlaw Variable Capacity control for five-step regulation of two-stage machines. Each cylinder of two-stage compressors is equipped with a single

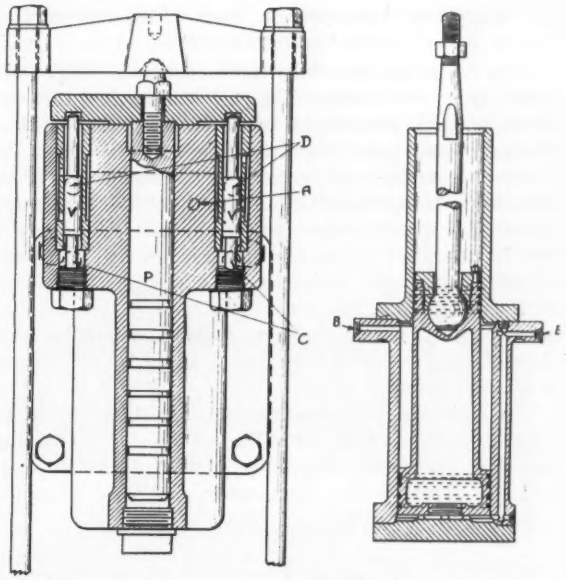


FIG. 10. GOVERNOR AND OPERATING CYLINDER OF A BYPASS CONTROL THAT ROTATES THE VALVE BODY

clearance chamber communicating with the crank end of the cylinder and designed to reduce the capacity of that end 50 per cent. The arrangement of the valves and clearance pocket around the cylinder is shown in Fig. 11. When operating, the control functions simultaneously on both high and low-pressure cylinders to maintain constant intercooler pressure and the proper division of work between cylinders. As the demand for air decreases, air pressure is admitted to the inside of the spring-loaded clearance pocket valve and holds it open to reduce the capacity of the machine to 75 per cent. The second, or half capacity step, holds the suction valves open on the same, or crank, end of both cylinders, while in the third step, the clearance pocket control is held open but the suction valves on that end are released simultaneously with the opening of the suction valves on the opposite or head ends. The head end is then completely unloaded, the crank end half unloaded, so that the capacity of the machine is 25 per cent of normal. Zero capacity is obtained by holding the suction valves in both ends open.

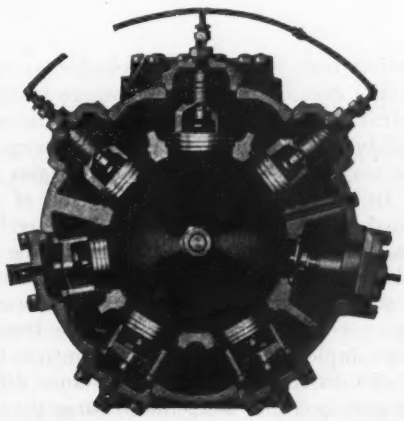


FIG. 11. CLEARANCE POCKETS AND VALVES ARE ARRANGED RADIALLY AROUND THE CYLINDER HEAD

Governor Actuated by Water Pressure to Give Positive Control

Control is automatically provided by a single governor, the cross section Fig. 12 illustrating the construction and method of operation, together with a schematic diagram of the air, piping and cylinders. Air pressure from the receiver acts on the under side of the diaphragm to operate the pilot valve of the main regulator. The governor is actuated by water pressure so that its operation of the air valves is positive. Pressure in the receiver may be varied by changing the position of the weight on the lower arm and, as air pressure operates only the pilot valve, regulation can be made close although a usual variation of about 1.5 lb. pressure is allowed between steps.

By omitting the clearance pocket in the cylinder, the bypass control can be used alone to give, on a two-stage machine, the usual three-step control or, on a single cylinder straight line compressor, complete unloading by wedge 41 closes pilot valve 39 through the compensating mechanism, making it necessary for another change in pressure to act on the diaphragm to operate the pilot valve again. In this way it is impossible for a machine operating at 50 per cent capacity to jump up to full load and then drop back to 75 per cent, when a sudden pressure drop occurs.

Two Pockets May Be Used to Give the Same Result

A somewhat different arrangement of clearance pockets and bypass control is used by the Chicago Pneumatic Tool Co., in its five-step capacity regulator, used

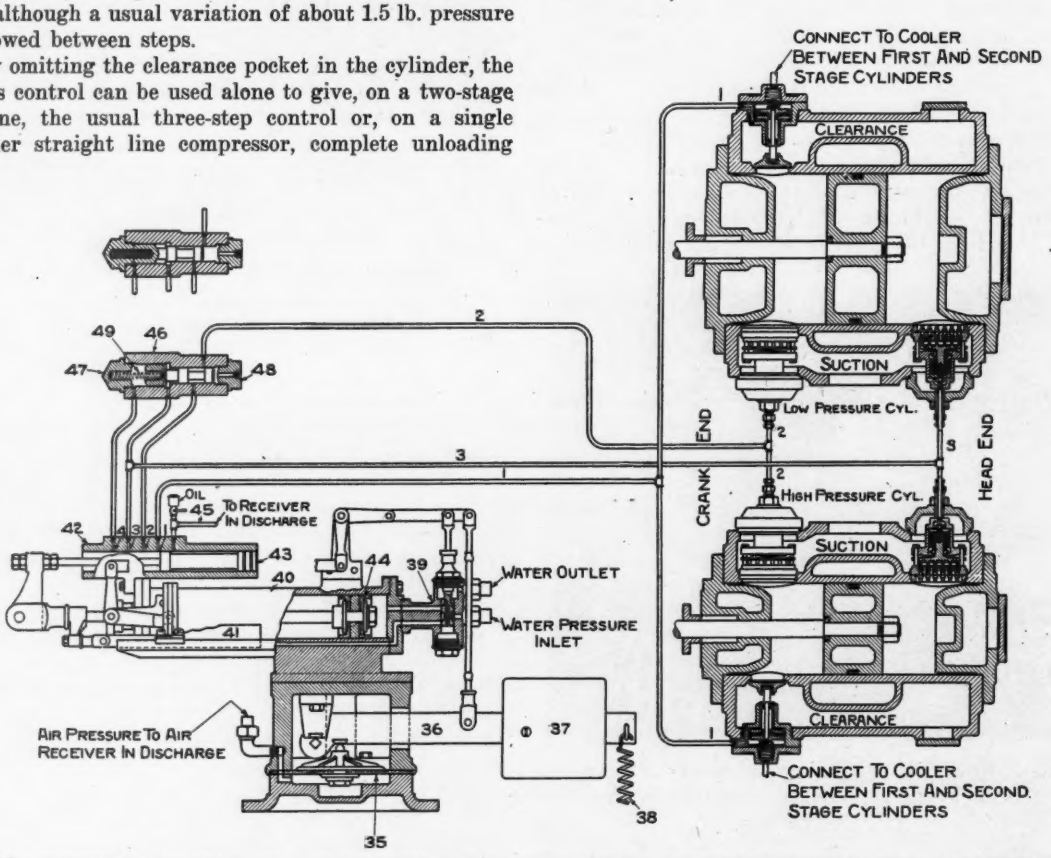


FIG. 12. SCHEMATIC DIAGRAM OF A COMBINATION CLEARANCE POCKET AND BYPASS SYSTEM WITH A POSITIVE TYPE WATER PRESSURE GOVERNOR

by unloading both ends of the cylinder at the same time. In the case of duplex single-stage machine, the same control can be used, the two sides unloading at slightly different pressures to give three-step, or the four ends may be unloaded separately to give five-step control. In the latter case, the crank end of one side is unloaded first, followed by the head end of the same side, the crank end and head end of the opposite side in the order given. The positive type water pressure governor is used with all five-step controls on Worthington compressors whether of the two-stage or single-stage duplex type. Three-step controls are operated by pilot valves with a usual pressure differential of approximately 3 lb. With the five-step governor the control must stop at each step and cannot pass over intermediate steps. In Fig. 12 the roller when lifted

on its two-stage, cross compound compressors. The right side of each cylinder contains two clearance pockets separated from each other by a partition and from the main air intake passage by plain inlet valves. Communication between these pockets and the cylinder bore is controlled by unloading inlet valves and air passing to the cylinder from the clearance pockets goes through both sets of valves. Proportions of the pockets are such that, when in communication with the cylinders, the capacity will be halved.

On the left side of the cylinders the main air intake passage is separated from the cylinder bore by unloading valves which, when held open, reduce the capacity of that end to zero. At full load, all inlet valves operate as plain valves, while at 75 per cent capacity, the clearance pocket unloading valves of the low-pressure

crank end and high-pressure head ends are held open. The next step is to open the unloading valves on the left side of the same cylinder ends so that the capacity of the low-pressure crank end and the high-pressure head end are zero. For 25 per cent capacity, the clearance pockets on the remaining two ends are opened while at zero capacity all inlet valves on both ends of both cylinders are held open. A pressure regulator or governor of the diaphragm type controls the unloading of the valves. Receiver pressure is regulated by weights and the receiver pressure acting on the diaphragm moves the regulator forward under pressure increments of about 3 lb. to uncover air ports in sequence and unload the proper intake valves.

Two Low Pressure Cylinders Used on One Machine

Although the usual bypass control is but three-step, the Bury Compressor Co. obtains five-step regulation by means of a three cylinder machine. Two low-pressure and one high-pressure cylinders are used, each end of each cylinder being equipped with an unloading valve as shown in Fig. 13. Each of the four low-pressure cylinder ends has an independent valve set to operate on pressure changes of 1 lb. or more, which unloads the suction valves of the low-pressure cylinder in the order A, B, C, D. These regulators automatically control the unloading of two similar valves on the high-pressure side, one high-pressure end unloading after two of the low-pressure ends, so that there is small variation of intercooler pressure.

Many of the smaller machines use only an automatic start and stop control in which the motor is started and stopped as the demand for air fluctuates. If the demand varies a great deal, these systems are sometimes combined with an automatic unloading device which automatically unloads the compressor when the motor stops and keeps it unloaded until the motor is again up to speed. Practically all companies build "start and stop," two-step, three-step and five-step controls to meet specific conditions of service, and the systems described were selected to illustrate typical methods, not to enumerate details of all the various control systems.

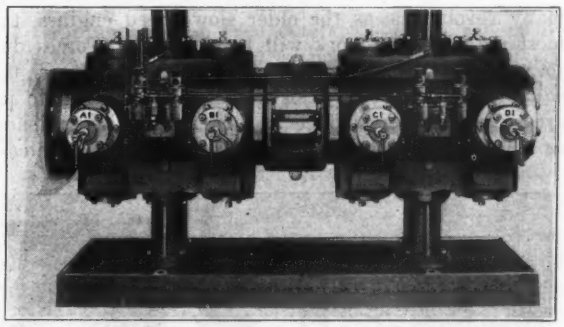


FIG. 13. THESE TWO LOW-PRESSURE CYLINDERS ARE USED WITH A SINGLE HIGH-PRESSURE CYLINDER AND A SUCTION BYPASS CONTROLS THE CAPACITY

With the exception of electricity probably no single item of power enjoys as wide an application as compressed air. Few industries are able to dispense with its use and the popularity of the direct-motor-driven compressor, often with a synchronous motor for power factor correction, is due largely to the use of rugged and flexible variable capacity controls.

Fundamentals of High Speed Oil Engine Design

Design Features Resulting from Three Years' Research. Importance of Good Workmanship and Good Metals Brought Out by Service Tests. By H. F. Shepherd*

OIL BURNING ENGINES operating above the traditional 750 to 950 piston ft. at mean piston speeds up to 1500 or 1600 ft. per min. may today be termed high speed. Strictly speaking, there is as yet no school of high speed oil engine designers. Automotive engineers, with a supply of gasoline still available at a fair price have not, in any great number given study to fuel injection. It has consequently fallen to the lot of Diesel engine designers to acquire the necessary training to build engines to operate at high speeds. As the demand for these engines arises from the market, it is not a result of promotion and may be regarded as a healthy product of the time.

In Fig. 1 is shown, superimposed, a slow speed oil engine shaft which the writer put into use 5 yr. ago, and the shaft of a high speed gas engine of the same rating, upon which he operated in consulting capacity a year later. With this experience as a basis, most of the past 3 yr. has been applied to research into a design of high speed oil burning engines. The research practice and even the economics of the situation have proved somewhat opposed to the writer's established views built up in the 20 yr. previous with heavy engines. For all the work of the last few years, there are few commercial products as yet, but a number of interesting points have been brought out.

*Diesel Engineer, The Bessemer Gas Engine Co.

High Speeds Demand High Grade Workmanship

Increasing the speed of the Diesel engine has developed nothing novel in a thermodynamic way while if

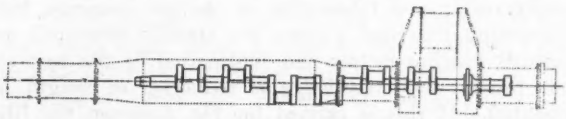


FIG. 1. COMPARATIVE SIZE OF HIGH SPEED AND LOW SPEED ENGINE SHAFT OF SAME RATING SMALLER SHAFT BEING THE HIGH SPEED ONE

testing reveals anything, it is only the necessity for wearing surfaces of genuine high grade workmanship, for first class metals properly heat treated and general design practice already well established in the automotive field.

The advance of injection for high speeds is little if any greater than for slow speed engines. The natural turbulence of the air charge seems to be stronger even at the same valve passage air velocities. This is per-

haps because less time has elapsed to damp it out. This is a pleasant surprise and removes one fear of the pioneer in this line, i. e., that the time interval would be too short for combustion.

Maximum pressure tends to run higher, and it is well to design for 750 lb. rather than for 600 lb. This is true of the aeroplane engine as well. Old time gasoline engines were designed to resist 400 lb. per sq. in., but 750 lb. is not uncommon in the aero engines of today.

If our high speed engines are to have a life of as many revolutions as the older slow speed engines, the most conscientious work will be required. Forces due to rotation and reciprocation increase directly as the square of the speed. It is not always practical to increase strength or surface to carry these greater loads, as mass increase overcomes any advantage. In the case

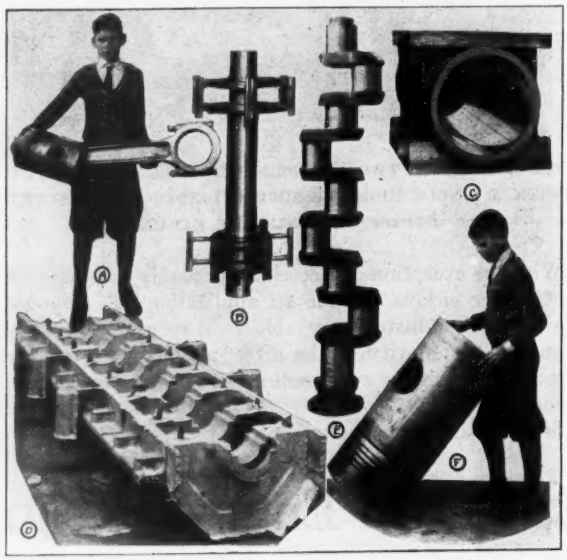


FIG. 2. PARTS FROM HIGH SPEED ENGINES, A. FORGED DURALUMIN CONNECTING ROD, B. HONE FOR FINISHING CYLINDERS OR LINERS, C. UNRETOUCHED PHOTOGRAPH OF HONED LINER, D. ALUMINUM BED PLATE CAST FROM REGULAR PATTERNS, E. CRANKSHAFT FOR AN 800 R.P.M. ENGINE, F. 16 IN. ALUMINUM PISTON

of the valve gears, much may be done with design, workmanship and lubrication of the pin bearings, but connecting rods and pistons are already developed as regards bearing metals and lubrication to the best of our present day knowledge so reduction of weight is essential. If this is carried too far, however, the life will be short.

Aluminum Castings Made with Same Designs and Patterns

It is quite obvious that a high speed engine will be a cheaper engine per unit of power if constructed to smaller, although sufficient, dimensions of the same material as are used for heavy engines, say, gray iron, S.A.E. 1020 steel for case hardened parts, and S.A.E. 1035 steel for forgings.

If lighter weight is a further requirement, aluminum or steel casting may replace gray iron for the main structure. Aluminum alloys can replace, at the most, three times their weight in cast iron, and usually but one half. Their cost will not be much less than 60c per lb. Steel castings for bed plates are not quoted, but have been tentatively offered at 25c per lb. with reservations for future orders. Malleable iron plates are being made in numbers for engines of moderate size, but the foundries are not ready to undertake anything larger.

There are high speed engine designs with a low price objective and high price and high speed engines built for the lightest possible weight. Fortunately the light weight in aluminum may be built in the same design and patterns as in heavy engines, so both aims may be met with only a price difference.

Regardless of what cost considerations may govern the main structure, the weights and designs of the reciprocating parts, pistons and rods, are fixed by the speed, although two strings of parts, a light set for high speeds and a heavy set for more moderate speeds may be used in the same engine design.

Piston Speed Alone Is Not a Rational Measure

Experience has shown that the mean terminal inertia should not exceed 100 lb. per sq. in. of piston area. It is true that the rods of double acting engines are put in far greater tension but the inertia load is a result of mass which is a measure of the shock at pressure reversal. Aeroplane engine designers have reduced piston weights so much in attaining inertias below this figure that piston life is a matter of hours.

Assuming $0.00034\ wrn^2 = 100$, for 250 r.p.m. and 750 piston ft. $w = 6.3$ lb. for 600 r.p.m. and 900 piston ft. $w = 2.2$ lb., for 800 r.p.m. and 1200 piston ft. $w = 0.92$ lb. while for 1200 r.p.m. and 1600 piston ft. $w = 0.61$ lb. The first engine may be built with a crosshead, the second with a substantial cast-iron piston and steel rod and the third with a sturdy light metal piston and a well designed steel or duralumin rod. The fourth demands far greater skill to reach the weight and at the same time provide ample strength and proper wearing surface.

Piston speeds multiplied by revolutions is the true measure of inertia forces. A high mean piston velocity reached by a long stroke results in far less free force than the same piston speed resulting from high revolutions. Here the designer must consider the driven machine. High generator or centrifugal pump costs for the introduction of a speed increasing drive may put the unit out of the market although the engine price is favorable. It is always well to design for synchronous speeds, say 600, 720, 900, 1200 r.p.m., as the available pumps and the like are so designed for motor connection.

Rotating parts, although balanced, deserve special consideration. Stationary engine bearings are usually well relieved at the joints and thus fitted, they are not well adapted to horizontal loads. At midstroke, when any crank is horizontal, inertia forces are about zero, and there is, except for the power stroke, no gas pressure except the negative work of charging or exhausting. This leaves the box and crank almost totally under the influence of centrifugal force on the horizontal direction on the joint. Fitting to a higher bearing or grooving helps this condition, but it is always advisable to reduce the force by babbiting directly into the steel

rod, using as little babbit as possible on account of the high gravity or by the use of duralumin rods.

Aluminum Pistons Not as Durable as Cast Iron

Cast aluminum alloy pistons are worth about $1 per lb. and the equipment cost is high. If the other engine organs are suitable for increasing speed, their use, by permitting higher speeds and rating, in the ratio of about 1.40 to 1 is economical. They are perhaps not as durable as cast-iron pistons in this use but in case of too close fitting or overheating, they are far less liable to ruin liners by scoring or to part rods by piston seizure. The crown must be supported, as the metal does not retain its strength above 600 deg. F.

For the same reason that the "rotating" end of the rod should be light, the crank end should be as light as possible, but due consideration must be given to tor-

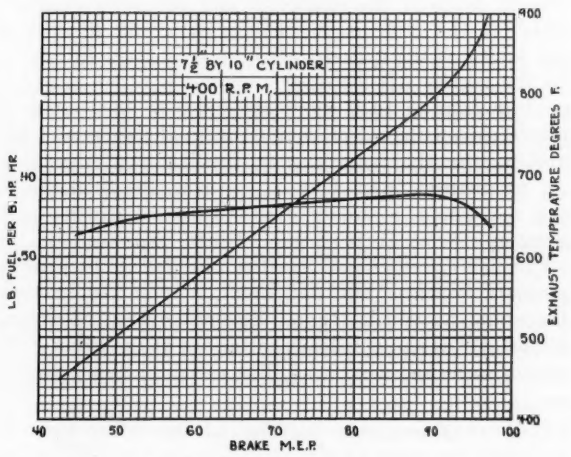


FIG. 3. TEST OF A 400-R.P.M. ENGINE WITH CAM OPERATED SPRAY VALVES

tional stiffness. It was once considered practical to pass through one or more criticals in the operating range, avoiding continuous running at these speeds. Today in rotating and reciprocating machinery, it is preferable to avoid criticals altogether.

Short shafts with large dimensions are the order of the day. The crankpin should be hollow to reduce centrifugal weight and the inertia of the shaft weight. Stiffness of a shaft can be proportioned from the known critical speeds of other shafts of similar design. Because of the necessity for great stiffness, stresses run very low in long shafts, and there is little use for alloy steel. We must always bear in mind that to double the natural frequency of the shaft it must be four times as stiff.

Crankpin Pressures Used as High as 1750 Lb.

As a factor of engine bearing design the pressure volume value has lost significance with the exclusive use of forced lubrication. By the use of the babbit metal developed by the Bureau of Standards, maximum pressures as high as 1750 lb. per sq. in. have been used on the crankpin without grief and without heating of the lubricating oil.

Dual valves are a requirement for designing Diesel heads for high speeds. With them there is no difficulty in allowing room for a central spray and in devising valve gears that will follow the cams up to 1200 engine r.p.m. with a spring tension not exceeding 12 to 15 lb. per sq. in. of valve area, figures that have long been in use.

Breaking in large high speed engines with a motor is not satisfactory; they should be so finished that little wearing in is required. Ground or honed cylinders may be run in under their own power without scoring the iron pistons or damage to aluminum alloy pistons. This is by no means uniformly possible with bored or reamed cylinders with small clearances.

Lapping has also been extended to cam rollers and pins, to pump plunger, spray needles and even to valve seats with great satisfaction. Valve seats holding 4000 lb. fuel pressure without any hand grinding whatsoever have been produced.

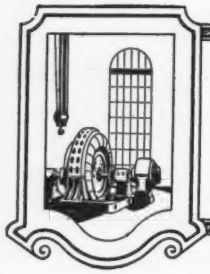
High Brake Mean Effective Pressure Possible

One factor of prime importance in producing light-weight engines is the high brake mean effective pressure. The writer has, in the past six years, built four high pressure cold starting engines. Two of them had displacer pistons and automatic sprays. Two had Diesel combustion chambers with automatic sprays centrally placed in the head. In direct comparison to those, he has undertaken for his education a series of tests on a line of engines with the Diesel form of combustion chamber and cam-operated sprays. Rated at the point of best economy, brake mean effective pressure capacities of the three types are, from the lowest to the highest in the order named, displacer pistons, automatic spray and cam-operated spray. A test carried out by George Monroe and checked by the writer is shown in Fig. 3. The method of taking fuel reading eliminates the end point and their accuracy is the accuracy of the tested commercial scales. A water brake was used and the tare carefully checked by operating with and against gravity.

What type of injection system is to survive the test of high speed is not yet shown, but unquestionably the cam-operating spray sets the pace for high rating and freedom from detonation trouble.

Co-operation means co-operation of one employe with all of the other employes as well as with the foreman.

The Engineer, London, of Jan. 14, announces that the Valley-road power station of the Bradford Corp. will be enlarged. The new unit is to operate at 1100 lb. gage pressure and 800 deg. F. temperature. Its evaporating capacity will be 75,000 to 94,000 lb. of water per hour. Divided chain grate stokers and compartmental balanced draft equipment is to be used but provision will be made for the use of pulverized fuel. Air preheaters and economizers are to be installed. At a pressure of 1000 lb. at the turbine stop valves, the steam will drive a 2500-kw. back pressure turbine which exhausts into the existing steam mains at 210 lb. The high speed plain impulse turbine will drive a generator at 1000 r.p.m. through reduction gearing. The capacity of Valley-road power station will thus be increased from 64,000 kw. to 91,500 kw. The high pressure unit is to be completed about March, 1928.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Features of New 132,000-Volt Cable Joint

A New Form of High Voltage Joint Utilizing Metal Cones Made of Tin Foil to Reduce Electrostatic Stresses. By Donald M. Simons*

BEFORE TAKING UP in detail the construction of the cable joint which is the object of this article, it is necessary to refer briefly to the manner in which cable joints break down. In Fig. 1 is shown a diagram

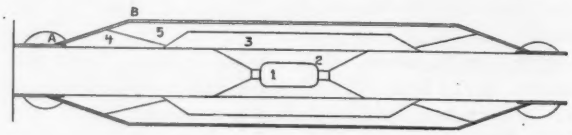


FIG. 1. DIAGRAM SHOWING THE VARIOUS INSULATING REGIONS IN A TYPICAL CABLE JOINT

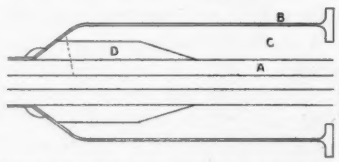


FIG. 2. FAILURE OF THIS END SHELL OCCURRED ALONG THE DOTTED LINE

of a cable joint in which the two conductors are joined mechanically by connector No. 1. In any single conductor joint of this kind, the first problem is to insulate region No. 1. The classic methods of preparing the cable ends are to pencil or bevel the insulation as shown in the drawing, or to cut the surfaces into strips. When this is done, additional insulation must be applied, and this is shown as made up of insulation No. 3 which is ordinarily supplied in tape form.

As voltages go up, however, a point of weakness appears, due to the concentration of stress at a point where the diameter of the outer electrode changes under the slope AB in Fig. 1. For medium voltages it becomes necessary to bell out the lead sheath, thus reducing the stresses at this point. Even this, however, does not remove all the difficulty. As voltages become higher it is found that the oil or compound in the region where the lead sleeve tapers under the slope AB would be over-stretched, break down and would lead to eventual breakdown of the cable at that point.

This phenomenon is rather an interesting one and is apparently due to the fact that a liquid insulator has the characteristic that its breakdown strength decreases with thickness. Of course, the breakdown voltage will increase the thicker the layer of liquid. Thus its specific strength will decrease. A certain voltage is impressed between the conductor and the outer electrode which in the cable is the cable sheath, and in most of the joints, is the cylindrical surface of the joint sleeve. In the region AB, however, there is a taper and proceeding from A to B more and more of the voltage is impressed on the oil or compound in the joint and less and less on the factory made insulation of the cable. As we proceed from A to B, however, the thickness of the oil which is under stress becomes greater and greater. From A to B the voltage impressed on the oil becomes greater and greater, and yet its breakdown strength becomes less and less. A point is reached, therefore, at which the oil becomes over-stressed and breaks down, and this leads to failure of the cable. The author once had a striking illustration of this principle

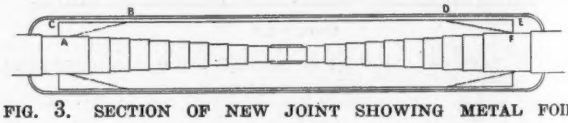


FIG. 3. SECTION OF NEW JOINT SHOWING METAL FOIL CONES AB AND DF

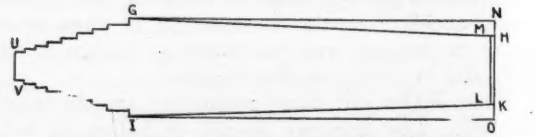


FIG. 4. LONG, UNROLLED, SINGLE SHEET OF IMPREGNATED PAPER, UGNOV, USED TO INSULATE THE JOINT OF FIG. 3 (TO A VERY DIFFERENT SCALE)

The region to the left has been cut so as to fit the steps of the joint when the sheet is rolled around the joint. The lines GH and IK are thin strips of tinfoil cemented to the paper. The region HKLM is covered with tinfoil.

in developing some extra high voltage cable terminals. The occurrence is illustrated by Fig. 2 which represents the metallic end bell at the bottom of a terminal. A is the conductor, B is the end bell. The end bell was filled in the space C with oil and of course breakdown would have taken place in the region where the taper of the end bell approached the cable surface had we not taken some precaution to relieve the condition. This region, therefore, was wrapped with saturated fibrous material in the mass marked D. The diameter of this wrapping could not be increased further as we desired, because of a projecting flange at the right of C, but we hoped that we had enough there to relieve the condi-

*Standard Underground Cable Co. An abstract of a paper presented at the Winter Convention of the A. I. E. E., New York, Feb. 7-11.

tion. Voltage was supplied, and breakdown took place as shown by the dotted line. In other words, the puncture took place through an inch of cable insulation, about 1½ in. of saturated fibrous material and about one inch of oil rather than in the cable itself, where we had merely one inch of insulation.

It will be seen, therefore, that in a very high voltage joint not only must the regions No. 2 and No. 3 of Fig. 1 be insulated, but steps must be taken to insulate the regions under the tapering section of the outer sleeve AB, namely the two regions No. 4 in Fig. 1. The taping by hand of the region No. 2 No. 3 and the masses of insulation No. 4 at each end of the joint and the application of metals to the outer surface of the latter section is something which requires time. The building up of large masses of insulation by the hand application of thin tape is a slow process.

The New Joint

In the new joint which will now be described, the insulation in No. 2, No. 3 and the two regions No. 4, as well as the metallization is all done by applying one sheet of insulation and this is applied by machine. The joint is shown in Fig. 3. The length of the joint is about 40 in., the distance from edge to edge of the sheath being 38 in. and the inside diameter of the lead sleeve being 5 in. The length of the applied insulation CE is 35.5 in. and its thickness EF is 1 in. An ordinary connector is used and a few layers of ordinary hand-applied tape and saturated twine are applied over the bevelled ends of the connector, filling up the lowest steps until a smooth cylinder is obtained. From that point on up to the surface CE a long roll of paper, the full width of the joint, is wrapped around, this being one continuous operation with one piece of paper, shown diagrammatically in Fig. 4. This long sheet of impregnated paper, which is 165 ft. long and 35½ in. wide, could be cut in advance as shown in Fig. 4. Actually it is cut by machine as it is being applied, making a perfect fit. Referring to Fig. 4, lines GH and IK have been metallized, and also the region HKLM. It should be pointed out that Fig. 4 is quite diagrammatic, as in the actual roll the ratio of length to width is about 11 times as great as in Fig. 4. When, therefore, this wide roll of paper is wrapped around the joint in its final condition, it will be obvious that there will be formed in effect a solid tube of paper containing metal cones. AB and DF in Fig. 3 are the metal cones imbedded in the tube and the entire outer surface of the applied insulation BD will also be metal covered, due to the metallized region, HKLM. The metal sleeve is applied as usual.

As to the details of applying the wide roll of paper to the steps, and the latter part containing the metal, this is done by the machine shown mounted in place in the manhole, Fig. 5. The cable end can be seen whetted together by the connector in the middle with the insulation cut into a series of strips. At the top of the machine is a wide roll of metallized paper, and on the bottom rods can be seen the knives for cutting the paper to fit the steps; also the two V-blocks which bear against the steps and hold the cable central in the machine against the tension of the wide paper.

The two cable ends are stripped to have enough conductor exposed at the end to permit their being jointed together with a copper tube which is sweated to both of them. The lead sheath is then removed for the required distance from each end and the necessary number of steps are cut in the cable insulation by hand, though it is planned to do this by machine also. The machine is then clamped onto the cable and in its latest form it is supported by brackets which are held by the same vertical rack that holds the cable. After the strips have been cut, saturated twine and a few layers of paper tape are applied over the conductor to build it up to a smooth cylindrical surface at about the level of the lowest step. Perforated tin foil is then applied to the cable insulation for a few inches at each end, adjacent to the lead sleeve and grounded. The foil is perforated so as to offer an easy path for the flow of fresh compound from the joint to the cable insulation.

Then the wide roll of paper is put on the machine and the two small cutters are set on one of the tie rods directly opposite the shoulders at the first strip. The paper is drawn through the cutters by hand to cut a few inches of the right width and this attached to the hand-applied tape around the conductor. The machine is

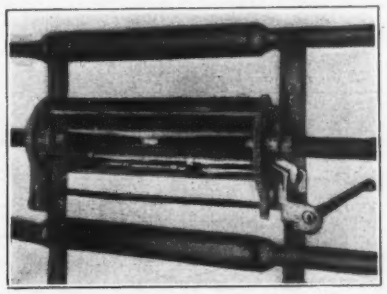


FIG. 5. MACHINE WRAPPING PAPER INSULATION IN STEPS

then started, being driven by motor or by hand. As the paper is rolled onto the cable, the two knives cutting it exactly to the width of the first strip, the spare paper at each side being cut off and thrown away as it accumulates. When the space between the first step is filled up, the cutters are moved onto the shoulders of the next step and the paper is cut to fit this, and so on until the paper has been wrapped up to the diameter of the original cable.

At this point strips of tin foil, which have previously been cemented to the paper, appear and these strips gradually taper inward, so that as the wide paper is applied a flaring cone of metal is formed in the body of the insulation itself. This metallic cone acts as an electrostatic screen to control the longitudinal and radial stresses. This is formed automatically without any attention on the part of the splicer in the field and it insures that all the insulation under stress is solid laminate paper insulation of the highest quality and breakdown strength, especially in the region where the diameter is enlarged from that of the cable sleeve to that of the joint sleeve.

Test Results

In the development of this joint there have been made and tested over 100 of the metallized tube joints. Table I gives the test results on all of the joints of the final design of cable insulated with 30/32-in paper. After completing this series of tests, tests on cable in-

sulated with 24/32-in. paper were started, and it was found that the breakdown strength of the joints was by no means as good. The failure invariably occurred at the joint rather than in the cable. After a series of experiments, it was found that with the higher stresses due to the thinner insulation, it was necessary to make the change less abrupt as the diameter enlarged in the joint. The angle between the cone of tin foil and the

TABLE I. EXPERIMENTAL JOINTS, SINGLE CONDUCTOR CABLE INSULATED WITH 30/32-IN. PAPER

Test Voltage	Time Hr.	Time Min.	Location of Failure	Remarks
200 kv.	28	0	joint	
200 kv.	23	27	cable	
200 kv.	31	60	cable	
200 kv.	30	8	joint	
200 kv.	15	38	cable	
200 kv.	8	25	cable	
200 kv.	17	40	cable	
200 kv.	16	28	cable	
200 kv.	30	30	cable	
200 kv.	48			Test discontinued
200 kv.	40	17	cable	

TABLE II. EXPERIMENTAL JOINTS, SINGLE CONDUCTOR CABLE INSULATED WITH 24/32-IN. PAPER

200 Kv.	220 Kv.	Time of Test 242 Kv.	266 Kv.	293 Kv.	Location of Failure
6 hr.	1 hr.	1 hr.	0		Terminal
6 hr.	1 hr.	41 min.			Terminal
6 hr.	1 hr.	1 hr.	41 min.		Cable & Joint
6 hr.	1 hr.	1 hr.	4 min.		Terminal
6 hr.	57 min.				Joint
6 hr.	1 hr.	1 hr.	6 min.		Cable

axis of the cable in the joint described above was 11 deg. for a cable with 24/32 in. of paper, expert test results could be obtained when the slope was decreased 7 deg. and Table II gives a tabulation of tests made on cable with thin insulation and modified slope of foil.

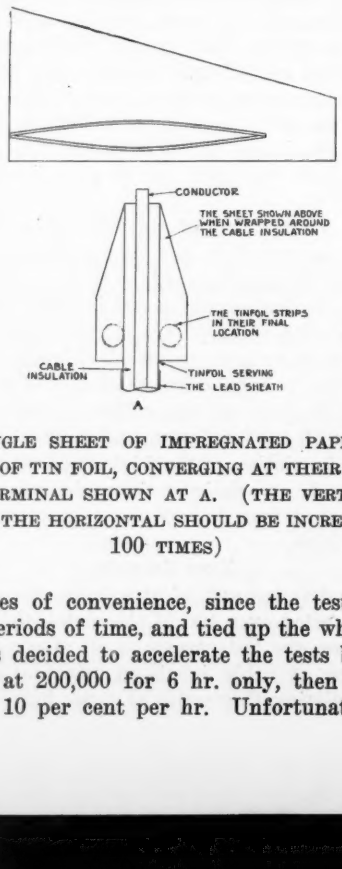


FIG. 6. SINGLE SHEET OF IMPREGNATED PAPER BEARING TWO STRIPS OF TIN FOIL, CONVERGING AT THEIR ENDS, USED TO FORM TERMINAL SHOWN AT A. (THE VERTICAL SCALE IS CORRECT; THE HORIZONTAL SHOULD BE INCREASED ABOUT 100 TIMES)

For purposes of convenience, since the tests took up such long periods of time, and tied up the whole laboratory, it was decided to accelerate the tests by keeping the voltage at 200,000 for 6 hr. only, then increasing the voltage 10 per cent per hr. Unfortunately it was not practicable to make a series of tests to tie together the two cables and make them directly comparable.

Metal Bearing Paper

In regard to the actual details of how the metal foil is applied, this can be done in various ways. A thin strip of tin foil can be applied on one or both sides of the sheath. The paper can be metallized by a spray process on one side, having been perforated so that the metal would go through the sheet. It could also be done in a very perfect way by metallic inlays so that the surface would be entirely smooth and there would be no building up of thickness at this point. In our joints we have used throughout the exceedingly simple method of cementing the one mil strip of tin foil ⅜-in. wide to one side of the paper. The principle embodied in the long sheet of paper, which when applied forms a cone of metal, has a wider application than merely to joints. It may be applied wherever it is desired to reduce stress by enlarging the surface of an electrode, and at the same time to insulate this enlarged surface. It has an obvious application in connection with terminals, either temporary terminals or permanent terminals for cables or in connection with bushings in general. One form we have tried out is illustrated in Fig. 6 where the line of metallization of the paper and a cross section of the completed terminal are shown. By applying metals to a wide roll of paper, as shown in Fig. 6a, and applying it to the cable, a complete porus can be formed which itself is insulated positively and definitely by solid insulation of high quality. This greatly reduces the stresses at the edge of the sheath and at the same time insulates the point to which flashover is likely to take place.

Automatic Operation of Synchronous Converters

Synchronous converters are usually started from half-voltage taps on the power transformers. When synchronous speed is reached, the converter field is flashed from a small exciter set to establish correct polarity. The machine is then made self-excited and at about half-normal field current the change-over from starting connection to full secondary voltage is made. The brushes are next lowered on the commutator and the machine balanced on the bus.

All of these equipments include protection against: (1) Severe alternating-current or direct-current overload; (2) failure to complete the starting sequence; (3) loss of excitation; (4) single-phase starting and undervoltage on the incoming line; (5) overheated bearings; (6) overheated machine windings; (7) temporary drop in the incoming voltage; (8) wrong polarity; (9) overspeed, and (10) reverse power.

The protective features are of two kinds: automatic reset, and hand reset. If the trouble is likely to be of a temporary nature such as overheated machine windings, low alternating-current voltage, or overload on the direct-current side, a device is used which will automatically reset when conditions return to normal. If the trouble is likely to be of a permanent nature or such that the station should be inspected or repairs made before service is restored, a hand-reset device is used to provide protection.

Exciters for A. C. Generators

COMPOUND VERSUS SHUNT TYPE. CAPACITY NEEDED FOR VARIOUS GENERATORS. METHODS OF CONTROL

DIRECT CURRENT generators intended for use as exciters for alternators may be either of two types; shunt wound or compound wound. Which of these two types to use in a given case depends, as do most selections of this kind, upon the individual conditions existing in the plant and, to a certain extent, upon the preferences of the buyer. Both types operate successfully if applied properly and both can be adapted to meet various requirements.

Nevertheless, there has been considerable controversy over the relative merits of these two types of exciters. Some engineers are strongly in favor of using only the shunt wound machine, basing their preference upon its comparative simplicity as regards connections and upon its reliability. These engineers claim that the compound machine is subject to certain disturbing influences which, if not guarded against, will cause serious operating difficulties. The compound wound unit, however, possesses certain advantages in its ability to maintain constant bus voltage.

While it is difficult to draw conclusions, from an examination of various opinions expressed by various engineers in technical papers and before engineering societies, the shunt generator seems to be the preferred type where parallel operation is desired. When compound generators are required to operate in parallel certain conditions must be maintained. The saturation curves and voltage characteristics of the units must be identical and the equalizer connections must be perfect. If these conditions are met, there will be no difficulty of operation. When used individually, compound exciters will give reliable and satisfactory service.

In stations where a number of exciters of different capacities or of different characteristics are required to operate in parallel, the shunt wound exciter will give the most reliable service.

Exciter Capacity

The exciter capacity installed in any plant depends upon the size of the plant and the types of generators used. Small, low speed alternators require up to three per cent of their capacity for excitation. Large, high speed units, on the other hand, require as little as 0.5 per cent.

Summerhayes, writing in the General Electric Review in 1920, gives the required exciter capacities for various conditions as follows:

	Per Cent
Steam Turbo-Generators	
1000 to 5000 kv.a.	0.5 to 0.3
7500 to 35,000 kv.a.	0.4 to 0.3
Waterwheel Driven Generators	
1000 to 5000 kw. low speed	1.5 to 0.8
1000 to 5000 kw. high speed	1 to 0.5
7500 to 20,000 kv.a. low speed	0.7 to 0.5
7500 to 20,000 kv.a. high speed	0.5 to 0.4
Motor Generators	
100 to 5000 kv.a.	1 to 0.5

Modern exciters are usually continuous rated machines having no stated overload capacity, so that in order to allow liberal margin for emergencies of operation the full load rating of the exciter should be 20 per cent greater than the stated excitation requirement.

Spare Capacity

In regard to the question of the amount of spare exciter capacity to provide there has been a wide variation from zero to 100 per cent spare capacity. Considering the fact that the modern exciter is an extremely reliable piece of equipment, 100 per cent spare capacity seems entirely too much, although some spare exciter capacity should be provided. In the case of exciters direct connected to high speed turbo-generators, the additional capacity does not cost much but the switching equipment necessary to provide a flexible arrangement may add appreciably to the expense. In a number of modern stations, using the unit system, the main generators have been equipped with direct connected exciters and a spare motor or turbine driven unit installed capable of exciting the largest generator in the station. This seems a satisfactory arrangement.

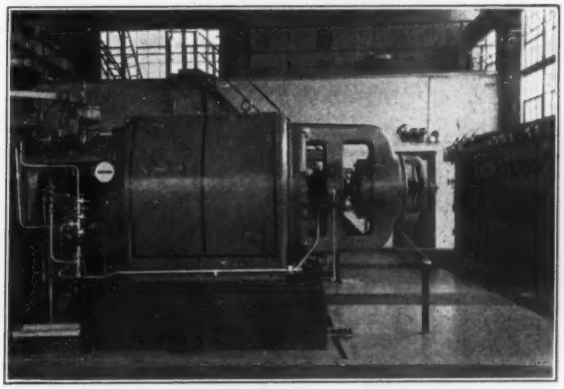


FIG. 1. THE DIRECT CONNECTED SHAFT EXCITER MAKES A CONVENIENT AND DESIRABLE ARRANGEMENT IN TURBINE PLANTS

Considerations regarding the size and type of plant also influence the selection of exciter voltage. One hundred and twenty-five volts is in common use except in the largest stations where 250 v. is used. In the latter type station, 250 v. is preferable because of the reduced cost and size of apparatus and cables. The choice of exciter voltage is not a matter of great importance but there are cases where one voltage is more desirable than another. A given machine requires a certain kilowatt excitation regardless of the voltage so that with the higher of the two voltages in common use a lower current is needed, consequently a smaller conductor may be used. In a large capacity unit this is an advantage but in a small capacity machine it may result in a wire of such small cross-section and in a coil of so great a number of turns that an excessively large space is taken up by insulation. The size of the alternator itself has a bearing on the exciter voltage in the fact that on small generators it is difficult to bend on edge the thin copper strap which is used for the

field coil windings. In the same way in very large turbo-generators, the limit is reached in the other direction. That is, if 125 v. is used for excitation, the current becomes so large that difficulties in current collection are encountered. In order to accommodate a large current it becomes necessary to equip the machine with heavy collector rings and a large number of brushes.

Of more importance than the choice of voltage is the voltage range of the exciters. In alternators of modern design the range of exciting current required at unity power factor is approximately 1½ to 1; and about 2 to 1 at 80 per cent power factor. This means a range in exciting voltage of about 2½ to 1 at 80 per cent power factor; and in more exceptional cases the range in exciting voltage may reach 3 to 1. A still

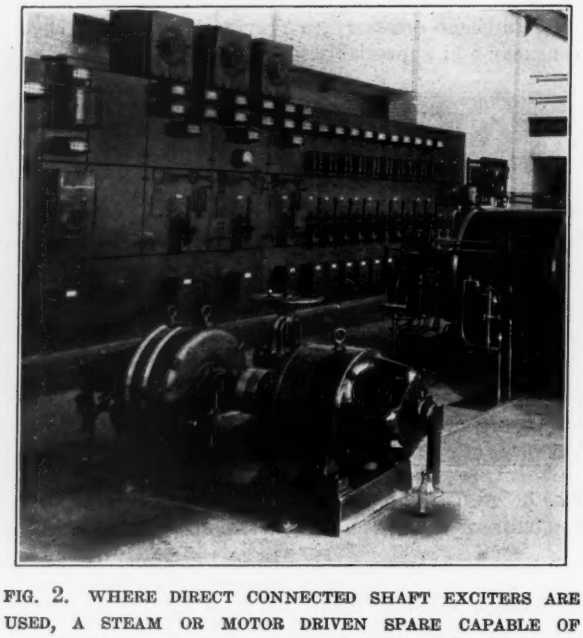


FIG. 2. WHERE DIRECT CONNECTED SHAFT EXCITERS ARE USED, A STEAM OR MOTOR DRIVEN SPARE CAPABLE OF EXCITING THE LARGEST GENERATOR IS DESIRABLE

greater range in exciting voltage may be required by generators or synchronous condensers which have to supply charging currents to transmission lines at light load. Here a range in exciting voltage down to the residual voltage of the exciter may be required.

When the a.c. generators are excited from a constant voltage bus, however, the question of voltage range is of less importance, since in that case the exciters are required to operate at one voltage only. Under these conditions the exciters may be operated well above the bend in the saturation curve so that good stability is secured.

Control of Exciters

The method of controlling the exciting current with respect to the current in the main generating field depends upon the type of exciter system used. In cases where a common excitation bus is installed, rheostats must be provided for both the exciter field and the main generating field. The rheostat in the exciter field is usually small in range and is used to maintain a predetermined and constant exciter bus voltage for good parallel operation of exciters. The rheostat in the main generating field has a wide range of small steps and is employed for controlling the voltage regulation of the main generating unit. Sometimes the exciter field rheostat is adjusted to assist the main field rheostat in meeting the excitation requirements of a heavy load on the main generator but all ordinary load demands can usually be met by means of the main field rheostat alone.

Where individual exciters are used, the main field current is controlled by means of the exciter field rheostat alone. The exciter field should be designed liberally and the rheostat made capable of adjusting the exciter terminal voltage through a wide range in order to meet occasions like the dropping of the exciter voltage due to abnormal slowing down of the main unit on account of heavy overload or low steam pressure. With exciter field control a comparatively small rheostat performs the duty which otherwise would be required of a large and inefficient main field rheostat.

In stations where all machines are excited from a common bus, however, it is usual also to install a main field rheostat for each unit. These main field rheostats are normally inoperative and are provided primarily for use in emergency cases. If trouble occurred on the excitation bus, for instance, and it became necessary to excite the generators from a new source, then these main field rheostats would prove useful. It is evident then that with individual excitation systems, the main field rheostat is unnecessary but with systems using the common exciter bus, it is quite essential.

For small exciters and generators, rheostats are usually hand operated, being mounted on the back of the switchboard or are installed above or below the board and operated by a chain drive from a handwheel. In large plants the main field and exciter rheostats are nearly always operated electrically. This method is not only satisfactory from an operating standpoint but lends itself admirably to arrangements where the control board is on another floor or distant from the machines.

When used with automatic voltage regulators the exciter field rheostat is generally made three to four times the ohmic resistance of the exciter winding, which is from two to two and a half times the resistance furnished with ordinary d.c. generators not used for exciter purposes. For common excitation plants with hand voltage regulation where the a.c. voltage is controlled by the alternator field rheostats, the exciter rheostats may be of ordinary design with resistance points closely graduated from 85 to 100 per cent of full exciter voltage and further apart for lower ranges. With individual exciters where no voltage regulators are provided and where no main field rheostats are installed, the exciter rheostats should have closely graduated resistance steps all the way down to 30 per cent of full voltage. In such cases the alternator rheostats may be omitted but it is considered better practice to install them for emergency use in case some other source of excitation is resorted to.

The use of automatic voltage regulators is highly desirable for a number of reasons, some of the most important of which are:

Constant bus voltage may be maintained or, by the use of line drop compensators, line drop in a main feeder or transmission line may be compensated to meet

load conditions. Cross current between generators may be kept to a minimum, or eliminated. The stability of the power system, as a whole, meaning the ability of various generators or generating stations to stay in step during system trouble, or pull back into step after system trouble, is increased.

In a unit system an individual regulator is desirable for each unit and either a spare regulator (and for emergency use it is advisable to provide a spare regulator for use with the spare exciter) or else a means of transferring the contacts of each regulator to the spare exciter. Exciters to be suitable for operation with a voltage regulator are made usually to operate at low saturation, i.e., on the straight part of the saturation curve. For this reason such machines do not have a wide range of stable operation under manual control.

Pneumatic Cleaning System in Big Soux Plant

Safety and Cleanliness, as Well as Economy, Are Features of This Cleaning System

IN ORDER to reduce the cost of cleaning and to maintain a high standard of safety and cleanliness, a pneumatic system of dust removal was installed in the Big Sioux Station of the Sioux City Gas & Electric Co., Sioux City, Iowa, about six months ago. This consists of a centrifugal ball-bearing vacuum producer direct connected to a 20-hp., ball-bearing motor. A vacuum of 5 to 9 in. of mercury is maintained on a pipe line leading to various parts of the plant.

This station is a 20,000-kw. plant, consisting of two 10,000-kw. turbines for which steam is supplied by three 1112-hp. pulverized coal burning boilers.

Locations of Openings

In the initial installation were 36 openings. This is now being increased to 48, located as follows:

1—Hoist room	4—Turbine room
2—Crusher room	4—Evaporator floor
5—Conveyor loft	4—Pump room
2—Pulverizer room	1—Cable room
2—Exhaust fan floor	3—Control room
3—Drier room, lower floor	1—Lavatory
3—Drier room, upper floor	1—Store room
4—Boiler room, main floor	1—Assembly room
4—Boiler room, basement	3—Offices, etc.

This system, which is the product of Allen & Billmyre Co., Inc., is capable of operating six openings simultaneously. At various locations there are sections of metal and rubber hose to which are attached floor brushes, wall brushes and various types of nozzles suited to cleaning pipes and machinery. Metallic hose is used throughout the plant, with the exception of the control room, where danger from live parts makes the use of rubber hose advisable.

Method of Cleaning

Five operators are engaged in cleaning floors, walls, pipes, boilers, stairs, machinery, electrical equipment and even window shades of the plant with this system, one being employed in the mill house, one in the main boiler room, one in the turbine room, one in the lavatory, locker room, corridors, etc., and one for general cleaning.

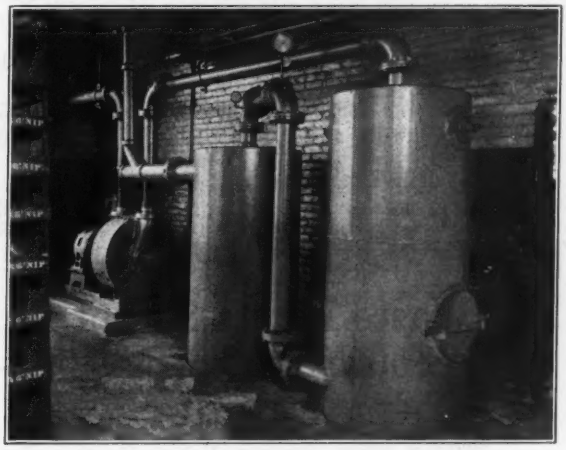
In addition to the above men, the workers in the mill house assist in keeping that part of the plant clean.

Dust is drawn by the exhauster into a primary dust separator of the vertical or centrifugal type, which precipitates the heavier material into a conical bin and passes the air and finer dust to another separator of the filter type. This latter separator contains seven cloth bags with a dust discharge into a conical bin below.

Once a day the dust is removed from the system, the average amount being 1320 lb. In a year this amounts to about 241 t. The dust is not utilized.

Cost of Operation

In the table, which was prepared by the A. C. Neilsen Co. in collaboration with Russell Robinson, chief engineer of the plant, is shown the annual cost of operating the equipment. Depreciation is calculated on the basis of 15-yr. life. Average interest is charged at 6 per cent. In six months' operation, two wall brushes, some new



PNEUMATIC CLEANING EQUIPMENT INSTALLED IN THE BIG SIOUX STATION

hose and other minor repairs have been required, and on the basis of this experience, it is considered conservative to allow $300 a year for repairs.

Cost of lubrication is negligible. The entire system contains only two moving parts and both operate on ball bearings which require lubrication only two or three times a year.

Work of removing the dust consumes about one hour a day, and is charged on this basis, although it is expected that certain contemplated changes will reduce this cost.

Power consumption has been estimated on the basis of three nozzles operating 12 hr. a day at an assumed cost of $0.02 per kw-hr.

The total cost of operation amounts to $5.15 a day, excluding operating labor.

Special advantage of the pneumatic system is noted in the coal handling departments where powdered coal, escaping from the handling machinery, forms a deposit which menaces the health and safety of employes, but the Tabco system has improved working conditions for all employes, particularly for those engaged in cleaning. This is especially true in the boiler room, where the job of cleaning pipes and boiler tops was so

disagreeable that it was often postponed until the dust had accumulated in dangerous quantities.

OPERATING COSTS OF DUST REMOVAL SYSTEM

Investment		
Equipment	$2,471.40	
Freight	74.82	
Installation costs to date:		
Material	624.43	
Labor	405.91	
		$3,576.56
To complete installation (est.)		210.00
Total investment		$3,786.56
Fixed Costs		
Depreciation—$3,786.56 ÷ 15-yr. life		$ 252.44
*Average interest at 6 per cent—16/15 × $3,786.56 × .06/2		121.17
Repair allowances—(hose, brushes, etc.)		300.00
Lubricant—(negligible)		.....
Maintenance—1 hr. × 365 days at $0.60		219.00
Total fixed costs		$ 892.61
Daily Operating Costs		
Daily fixed costs—$892.61 for 365 days		$ 2.45
Power—135 kw-hr. at $0.02		2.70
Total daily cost, excluding labor handling nozzles		$ 5.15

*Allowing for interest earned by depreciation reserve.

Mill Waste Lights Seventeen Southern Towns

WASTE FUEL OF THREE SAWMILLS RUNS MILLS AND SUPPLIES POWER TO 185-MI., 33,000-V. LINE SERVING LARGE GROUP OF TOWNS. BY GEORGE F. PAUL

TRUE ECONOMY in the operation of a sawmill is obtained when the waste is made to serve some useful purpose. This is true of the mills of the Dierks Lumber & Coal Co., located at Dierks, Ark., and Broken Bow and Wright City, Okla. Sawmill waste is now lighting the towns of Nashville, Dierks, DeQueen, Lockesburg, Horatio, Murfreesboro, Mineral Springs, Foreman, Cove, Gillham and Winthrop in Arkansas. It is also lighting the towns of Broken Bow, Wright City, Calliant, Idabel, Talihina, Oak Hill and Albion in Oklahoma. The three principal power producing plants are interconnected; this means that whenever production is interrupted at one point there is no serious inconvenience to users of electricity in these towns as the current from the other power plants is available. It is estimated that these lines serve a population of 100,000. The three main power houses are joined together by a 33,000-v. transmission line which forms the backbone of the power system. There is at present 185 mi. of 33,000-v. transmission lines.

FIG. 1. POWER HOUSE AT DIERKS, WHERE POWER IS DELIVERED TO THE 33,000-V. TRANSMISSION LINE THROUGH SUBSTATION IN FOREGROUND

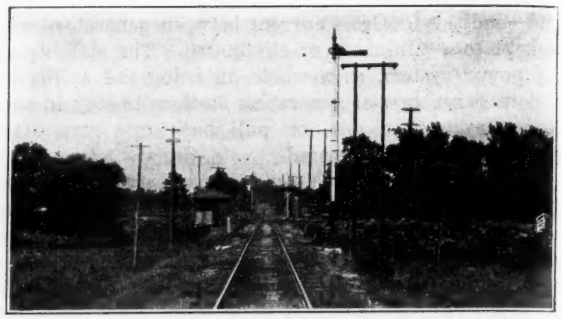


FIG. 2. TYPICAL TRANSMISSION LINE CONNECTING THE POWER PLANTS AND TOWNS

For many years a local power plant had been in operation at DeQueen, but the machinery was not capable of providing steady and dependable power. As electricity was used to pump water for daily use in the town, such a situation was unfortunate.

The citizens of DeQueen organized the DeQueen Light & Power Co. to secure the construction of a 27-mi. high voltage transmission line from Dierks to DeQueen. This company took over the lines of the local electric company. This new arrangement has resulted in uninterrupted service at a decided reduction in cost.

The fuel consists of shavings, sawdust, hogged waste and bark. It is estimated that this fuel has a moisture content of 45 per cent by weight and a heat value of about 5800 B.t.u. per pound of wet fuel. Four pounds of this fuel produce a kilowatt-hour. A load dispatcher divides the system load on the different power plants according to available fuel and general operating conditions. If one power house becomes short of fuel, he instructs the other power houses to take more load and thus relieve the situation.

The mill at Dierks, Ark., has a capacity of 150,000 ft. of lumber a day. Here are two 750-kw. turbo-generator units which drive all mill machinery with the exception of the "shotgun" in the sawmill, and also supply the transmission lines. At the Broken Bow mill is a 750-kw. turbo-generator unit and at Wright City are two generators, one 1000-kw. and the other 500-kw.

Approximately 450,000 kw-hr. a month are supplied to towns. This power is used by cotton gins, water pumping plants and other commercial purposes, and also for lighting purposes. The average lighting rate is 14 cents a kw-hr. and the average revenue from power users is 7 cents a kw-hr.

Revenue from power sales is not the only benefit thus derived. Power factor losses have been decreased. Before building the transmission lines the power factor at all plants was about 75 per cent, causing a large power loss in the cables and lowering the capacity of the generating equipment. Now the power factor of the system has been raised to 87 per cent. By connecting the plants with a transmission line, the total load on all three plants has been reduced 15 per cent. This comes from equalizing the load over the transmission line between plants. When the load on one plant swings to a momentary high peak, the load on another plant is probably swinging downward. The transmission of power between these two plants serves to stabilize what would be a fluctuating load. Furthermore, after 11 o'clock at night, and on Sundays, two power houses shut down and the third handles the load. Formerly, to light the mill towns, plants had to run 24 hr. a day, seven days a week.

It will thus be seen that the mill waste, instead of being a useless commodity whose disposal was often a serious problem, is now transformed into a positive benefit for the entire community, and the work of operating the mills is also simplified.

Water Hammer Causes Painful Accident

IN CONNECTING A LINE TO SUPPLY PURCHASED STEAM TO THE MAIN HEADER, WATER HAMMER WAS CAUSED BY WATER IN SEPARATOR OUTLET PIPE. BY ROBERT ALTHAUS

ON THE 18th of last December, I figured in a somewhat painful accident caused by water hammer in our boiler room steam main. The plant where the accident occurred is equipped with horizontal return tubular boilers which are fired with shavings and saw-mill refuse, the amount of steam produced varying directly with the amount of refuse delivered to the boiler room. In seasons when slack business fails to produce enough refuse to heat the kilns and supply the steam needs of the plant, additional steam is purchased from the next door plant. The purchased steam is delivered through a 5-in. steam main 1500 ft. long. The amount of steam turned out by our boilers at times runs as high as 12,000 lb. per hr.

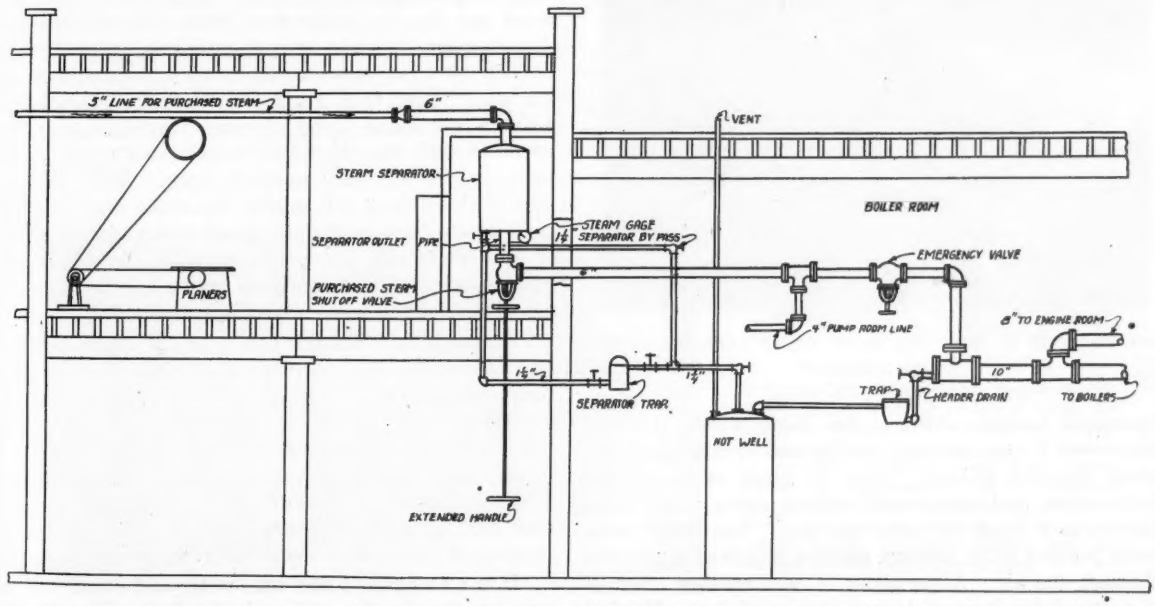


FIG. 1. ARRANGEMENT OF PIPING IN THIS PLANT AT THE TIME OF THE SHATTERING OF MAIN STEAM VALVE BY WATER HAMMER

On the day of the water hammer accident, the amount of mill refuse was low. The outside temperature was about 10 deg. F. and was slowly dropping. The offices were calling for more steam, so the only thing left to do was to purchase the additional steam from the neighboring plant. The necessary arrangements were made and men dispatched to the neighboring plant to open up the steam line. This line runs for at least 1000 ft. through the air and unheated sheds, making it necessary to use considerable care in heating up the main and drawing off the water of condensation.

Donning a heavy mackinaw and gloves, I accompanied the steam as it slowly warmed up the cold line. The numerous expansion joints all functioned properly and all seemed well as the steam began to show some pressure on the gage located on the purchased steam main at our plant.

Reference to Fig. 1 will show the arrangement of piping at the time when the accident occurred. The steam separator shown is of ample proportions, about 36 in. in diameter and 5 ft. high. About 2 ft. below the separator is located a standard angle globe valve of common make. This valve, which is used to shut off the purchased steam when necessary, has an extended handle through the floor to make it convenient for the fireman to regulate the amount of steam purchased.

The separator is equipped with a fairly efficient high-pressure steam trap and a bypass and discharges directly to the hotwell tank, which is vented to the atmosphere. Halfway across the boiler room is located a tee from which the pump room steam line is led. Next to this tee is an emergency shutoff valve, controlling the steam from our boilers. At the end of our boiler header is another drain to the hotwell.

As previously stated, when the steam was turned on and the line became warm, the pressure indicated by the gage under the separator began to rise. The separator bypass and trap were both working, the bypass being of 1¼-in. pipe. The pressure soon rose to 75 lb. From the rapidity with which the pressure was rising, I concluded that the 8-in. valve at the neighboring plant had been opened wide but, upon going down to the boiler room, I found the pressure on our boilers only 45 lb. I then told the fireman that I believed he could turn the purchased steam into his mains and help our

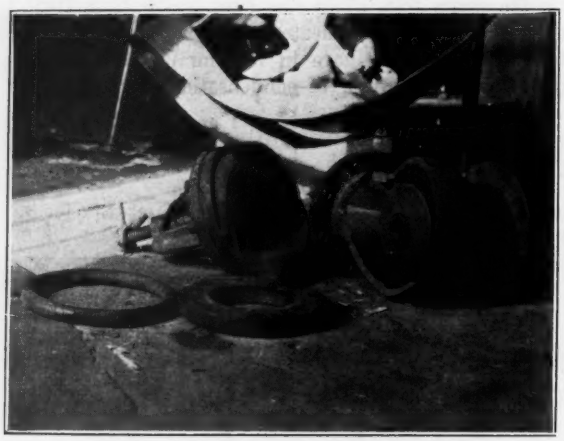


FIG. 2. THIS IS HOW THE MAIN VALVE APPEARED AFTER THE ACCIDENT

overtaxed boilers. After a few more words, the fireman went to the extended handle and opened the valve about one-half a turn. Then he came back into the boiler room and commenced talking again. Suddenly, there was a crash of water hammer. The boiler room main jumped in its hangers, sending clouds of dust down through the air. After about 30 sec. another crash of the same intensity sent down a shower of dust. My first thought was that the separator trap and bypass were choked. Rushing upstairs, I heard several other water hammer crashes. When I arrived at the separator house, I quickly tried the drain valves and saw that they were open. Then I stepped back from the separator to decide the next move.

Luckily I was still wearing the mackinaw with the collar about my neck and gloves on my hands, for suddenly another crash came and with it an avalanche of hot water. The force of the impact threw me face forward on the floor. Right behind the water came a roaring stream of steam. Quickly jumping to my feet, I found the whole room clouded with steam and myself being pushed resistlessly across the room by the stream of steam. I ran into numerous obstacles and machinery as I was propelled across the room. Finally my hands struck the brick wall. The thought of being penned up in the countershafts and horizontal belts, which by the way, were still running because the frightened machine operators had not had time to shut them down, nerved me to desperation. I held the mackinaw collar around my face and hurdled and kicked blindly at the belts as I ran into them. After passing the last belt, I dashed in the direction in which I knew the door was. As I reached the door, I called to one of the foremen to telephone to the neighboring plant to shut off the steam. Then I ran to the boiler room and, climbing a ladder, shut the emergency valve by the pump room tee. Then for the first time, I noticed there was not a dry thread on my body. The hot water squashed in my shoes at every step. My first worry was how I was to get into dry clothes. As I stepped into the engine room, I noticed loose ribbons of skin hanging from my wrists and face. Then the engine room door flew open and a first aid crew burst in with antiseptics and bandages.

After I was able to return to work my first steps were to see just what had happened. What greeted my eyes is shown in Fig. 2. The last water hammer had completely shattered the purchased steam shutoff valve. It developed that the outlet pipe of the separator had filled with water and, when the valve was opened, this water ran into the boiler room main. If only the purchased steam had had enough pressure, it would have pushed the water down to the header drain and no notice would have been made of it with the exception of possibly a cracking sound of water hammer. As it happened though, the purchased steam valve at the neighboring plant was only partially open. After the first puff of steam from this source, the steam from our boilers began to back up the purchased steam and the stream of our steam into the pump room line held back the troublesome water, causing the water hammer that finally liberated the water with disastrous results.

Although this was the first time this same combination of conditions had occurred, I determined to make such changes that would make it possible to free the separator outlet pipe of the entrapped water. This pipe was tapped and a line led down to the floor below. A steam gage also was put there to show how much pressure was present on the purchased steam line. The fireman now drains this separator leg of all water before opening the purchased steam valve.

It is a recognized fact that water and steam will not stay together in the same main for long. The pressure either will distort the pipe and the water leak out through gaskets and other joints or else hammer its way to freedom. The foregoing experience emphasizes the importance of properly designing and equipping all steam mains and lines with the proper fittings. All boiler room steam main fittings should be chosen with due consideration of the service they are to perform.

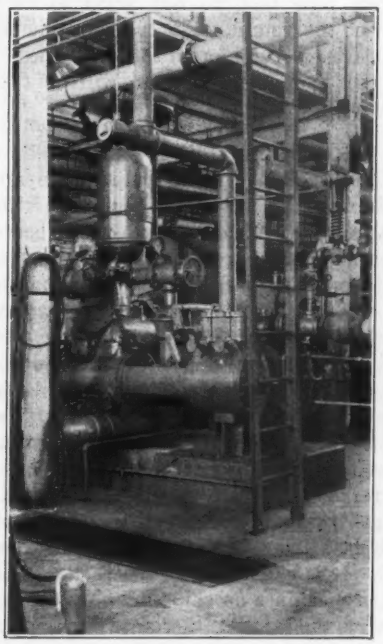
THE CROWN WILLAMETTE PAPER CO., San Francisco, Calif., is reported to have made arrangements with the Provincial Government of British Columbia for the construction of a new hydro-electric plant in conjunction with pulp and paper mills on the east coast of Vancouver Island. Plans will be drawn at an early date for the proposed hydro-electric development estimated to cost about four and a half million dollars.

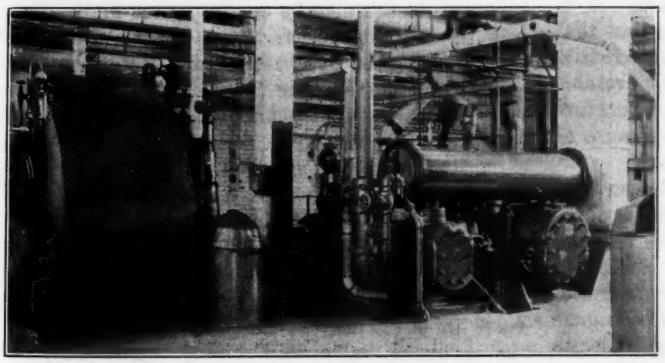
Seaman Body Corp. Burns Wood Waste and Produces Half the Power Needed for Its Large Automobile Body Manufacturing Plant

IN THE WELL-DESIGNED and up-to-date factory shown, Seaman Body Corp., Milwaukee, Wis., makes bodies used on the Nash car, obtaining a large amount of its fuel from the wood waste of the plant. Four vertical water tube boilers make steam for the plant, two of them being fired by coal burning stokers and two by wood burning stokers, with provision for storing hogged fuel and feeding it to all the furnaces if necessary.

A turbo-generator makes about half the electric power needed, the remainder being purchased. Exhaust from main turbine and various auxiliaries goes to mill and dry kilns and to feed water heater, suitable piping connections giving proper steam distribution and live steam makeup being added as necessary.

To supply compressed air for painting and pneumatic hand tools in the factory, air compressors are installed. Most of the boiler auxiliaries are installed in the turbine room. Feed water is heated in a 3000-hp. feed water heater and pumped to boilers by a 200-g.p.m. motor-driven centrifugal or a 200-g.p.m. duplex steam pump. A 10,000-gal. per hr. heater supplies domestic hot water. At right is shown the underwriters fire pump.

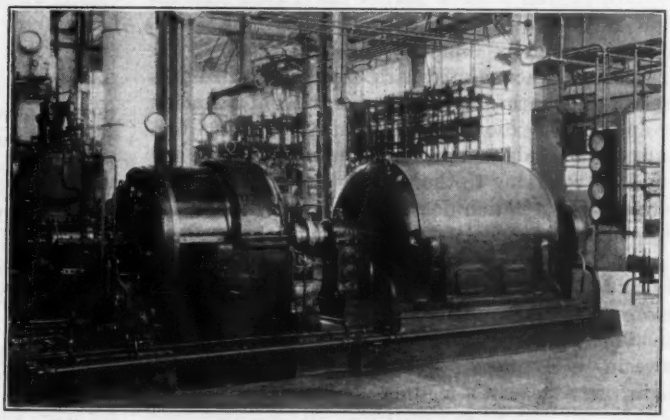




Left—One 33,000-c.f.m. engine-driven fan supplies forced draft for stokers. At right of this is a 1200-c.f.m. steam driven compound air compressor, and behind it a vertical 3-cylinder, 300-c.f.m. motor driven air compressor. The air receivers have aftercoolers to remove moisture from air used in painting. Steam and motor-driven vacuum pumps are installed for the heating systems.

Power at 480-v., 3-phase, 60 cycles is generated by the 1250-kv.a. generator shown at the right, driven at 3600 r.p.m. by a steam turbine taking steam at 175 lb. A direct-connected 125-v. exciter is provided. In the background is the switchboard for distributing purchased power. The company is now putting in its own board, not shown here. Static condensers of 200 amp. capacity are installed on the incoming lines. Incoming power at 13,500 v. is stepped down to 480 v. by a 1250 kv.a. transformer.

Wm. Iwer is superintendent of maintenance for the company and the power plant comes under his jurisdiction, with Nicholas Pung as chief operating engineer.



Pointers on Carbonic Refrigeration

A Discussion of Some of the Questions That Arise to Perplex the New User of CO_2 Refrigeration. By H. J. Macintire*

NOBODY appreciates the difficulties of refrigerants as well as the operating engineer who has to make repairs to a leaky flange, valve stem or gage glass in an ammonia system, nor is anyone as fully thankful for the innocuous refrigerant such as carbon dioxide as this same operating engineer. When the carbon dioxide gas blows into his face under these circumstances and he suffers no more discomfort than from a similar leak in a steam pipe line, he has much to be thankful for; however, the young engineer has a number of questions which arise to vex him on the properties of carbon dioxide, and a number of these will be taken up in the following.

Critical Temperature

The so-called critical temperature appears to be a stumbling block for many engineers. This is the temperature above which a gas cannot be condensed to a liquid no matter how great the pressure may be, and this temperature has the very nominal temperature of 87.1 deg. F. for carbon dioxide. In other words, it would appear that 80 deg. or higher temperature condensing water would produce a condition in the condenser where no liquefaction would take place, therefore no refrigeration would be possible. It is true that the gas will not condense under these circumstances, but it is not true that refrigeration would not be obtainable. The refrigerating effect will be decreased per pound of the gas, as shown on the P-I diagram on page 202 in the Feb. 1 issue of Power Plant Engineering, but that is all. It is evident from the fact that carbonic refrigerating machines on ships crossing the equator are able to carry their loads, therefore the critical temperature may decrease the capacity, but it never is the cause of entire loss of ability for refrigeration.

What, then, is the meaning of the so-called critical temperature? It is the boundary point between the liquid and the vapor. Below this temperature the substance can exist as a liquid and above the critical it cannot be called a liquid although it may have some of the characteristics of a liquid. Should there be a gage glass in the "liquid receiver" or on the condenser, a colorless liquid will be observed as long as the temperature of liquefaction is below that of the critical temperature but as the temperature approaches 87.1 deg. F., a cloud appears and the liquid disappears.

Engineers are acquainted with the temperature pressure relations of saturated vapors, like that of ammonia, steam and carbon dioxide, and that the boiling temperature corresponds to a particular pressure which may be found by referring to the tables. Above the critical temperature this relation does not follow any more than it exists in the superheated region where the temperature as well as the pressure must be stated in order clearly to define the conditions. The operating engineer has more trouble than enough with this property of carbon dioxide. With hot "condensing" water the pressure in the condenser is determined by the weight of gas in the system in a manner similar to the pressure in the after-cooler of an air compressor. Increasing the charge of the refrigerant, under these conditions, will increase the pressure which, incidentally, is the very thing that is done in marine practice as it is found that such a method gives a greater refrigerating effect per pound of carbon dioxide brought into the compressor than would be obtained otherwise. Referring to the P-I diagram, it will be seen that such an increased pressure and cooling to the same temperature in each case will increase the work of compression but the refrigerating effect increase will more than compensate for the power increase. The regular practice in marine compressors is to purge off the excess carbon dioxide on leaving the tropics; a habit which is a waste, nevertheless a necessity, because of the apology for a liquid receiver which is supplied by the manufacturers with carbonic condensers. If liquid capacity were supplied equal to the demands, there would be no need of throwing away any of the refrigerant which otherwise would flood the condenser and interfere with proper liquefaction.

Expansion Valve Opening Too Great

Another serious operating trouble is that due to a lack of charge, or its equivalent, when the condenser temperature is below that of the critical. The engineer notes that the condenser pressure is low in consideration of the outgoing water temperature, whereas the suction pressure may be correct or too high. The engineer thinks that the charge is low, and adds more gas with little effect except that the suction pressure increases and all the time the evaporating coils function more and more poorly and the temperatures begin to rise. The trouble is due to lack of liquid seal on the expansion valve or valves. In a plant with a number of expansion valves it is easy to get them out of adjustment. The gas flows through too freely and soon there is no liquid seal. The final result is that liquid and non-condensed CO_2 gas pass into the coils and very soon the expansion valve becomes simply a pressure reducing valve in effect as well as in name. Choking back on the expansion valves will remedy the difficulty and the engineer should remember that the expansion valve should be given the first attention in case of trouble.

Lack of Charge

A lack of charge is a similar cause of trouble and this follows the reasoning of the preceding. A lack of charge means no liquid seal on the expansion valve (even if the valve has the proper opening) and some or all of the compressed gas will pass through the condenser without liquefying. The refrigerating system becomes then simply one using a dense gas similar to the old fashioned air refrigerating machine without the use of the air motor. The result is a partial or total loss of capacity.

The result of troubles inherent in carbon dioxide have resulted in various tales of inefficiency in the carbon dioxide system. Most of these are really only troubles due to ignorance or carelessness. Carbon diox-

*Associate Professor, Refrigeration, University of Illinois.

ide as a refrigerant has its place. It is convenient in the production of low temperatures and it is innocuous. A loss of the entire charge in a marine engine room is not serious or inconvenient as far as the health or comfort is concerned, and the same is true of apartment houses, hotels and theatres. No person who has been exposed to a really bad break in an ammonia line would advocate putting ammonia in any installation exposed to the general public where panics could occur or easy and convenient escape from the fumes is not possible. It is said that carbonic systems require more power than ammonia does and this is correct for similar operating conditions although the amount of excess power need not exceed greatly 5 to 10 per cent. The loss of gas due to leaks can be prevented by eliminating flanges and by a little more than usual care. Wherever oil comes out of a flange or fitting it is evident that gas is escaping at this point.

Carbon dioxide has a place and a very definite place in refrigeration. Care in manufacture and erection and a knowledge of the properties of carbon dioxide are essential. There is no question but that carbon dioxide will increase in popularity as the troubles enumerated are understood and remedied.

The Night Engineer Finds a New Use for Ammonia

By A. R. Knapp

OTTO SHUMANN, night inmate engineer of the Central State Prison for men, stood in the doorway of the prison power plant and idly surveyed the mass of buildings and walls that he had been forced to call "home" for the past two years. He gazed across the yard to the towering cell house where a myriad of flickering lights reminded one of a modern office building at night. It was his duty every evening at 9 p.m., to throw the switch that plunged the cell block into darkness, and automatically still the low murmur of conversation that ran from cell to cell.

He turned into the engine room. It presented a peaceful scene in marked contrast to the hustle and confusion of the day run, when the power plant furnished light and power for a large foundry and chair shop within the walls. He studied the row of circuit ammeters on the long marble switchboard, closing the switch on the wall tower flood lights, and opening the circuit on a deep well centrifugal pump, the ammeter showing that the pump had dropped its suction. Behind him, No. 2 engine unit ground out power with only the droning click of the valve gear as the pawls engaged the dashpot hooks.

Suddenly he thought of the two pipefitters that chief engineer Terry had detailed on special duty that night to repair a leak in the line to the steam kettles in the mess hall kitchen. While he was in no wise responsible for the men, he felt it his duty to see that they performed the task allotted them by the chief. He searched in turn the pipe shop, machine shop, and boiler room. The ice plant, a favorite lounging place for the night crew, failed to reveal the pair.

Otto sensed that everything was not according to rule, but he had learned through bitter experience to keep his discovery to himself. The pair had been detailed on night emergency work before, and had never left the plant without notifying him of their plans. He gave up the hunt when an electric buzzer over the engine room desk announced that the gravity oiling system to the engines was due to be pumped again. He slipped down the iron stairway to a small oil room beneath the engine room floor, where was located the receiving tank, filter, and motor driven rotary oil pump. He was about to start the oil pump when a faint babble of voices came through a small opening in the oil room wall. He crept to the wall, and glued his ear to the opening.

"I tell you, Shorty, it's easier to get outer here than to get in," he heard through the wall, and recognized the voice of Connie, the pipefitter. "Simple as liftin' a wallet. I got it all worked out to a high polish. That steam leak in the tunnel is a blind. Made that leak myself this afternoon so as I could get out tonight. Now if you like the great open spaces better'n you do these 30-ft. walls, you are welcome to join me."

There was a pause in the conversation, and Otto crouched closer to the opening in the wall. "So! dot's der idear. Vell—chust vait!" he mumbled.

"Here's the plan," Connie continued. "We'll work on our steam line in the tunnel until the night crew goes to supper at 10:30. Otto and the hopper filler and pit cleaner eat first. That leaves only the head fireman in the plant. That's when we break for the outside. Here's how we go out. The main sewer fer this institution runs right past the engine room here. It cuts over across the yard behind the kitchen an' out through the wall. About thirty ft. inside the wall there's a manhole. An iron ladder down the side an' everything. It's big enough to crawl through at this point. At 10:30 there's very little water goin' out, onless the fireman happens to blow a boiler. I'll fix that. The boilers blow into an underground tank. I'll open the cleanout valve an' drain the tank beforehand. Get my drift, Shorty? We go down into the sewer when the rest is eatin', an' in ten minutes we are outside the walls. Where the sewer goes under the wall there is three 1 in. iron bars spaced 6 in. apart. Got that dope from Pittsburg Pete who cells next to me. He helped to build that sewer, an' he oughter know. An' listen," Connie continued in a whisper that was hardly audible through the wall. "I got two brand new saw blades hid. Swiped them from outer the vault when the chief's back was turned. With new blades we oughter saw through two of those bars in record time.

"Just outside the wall the prison sewer empties into the city sewer. We can travel through that as far as we like before comin' to the surface. Then there's our getaway. That's easy. Haven't you layed in your cell nights an heard that freight train bein' made up in the railroad yards not more'n a mile away She leaves every night at 10.55. By workin' fast we can make it. I've got three more years to do here, an' I think I'll take a chance on the freight tonight."

"Everything looks lovely," Shorty agreed.

The conversation ceased, and Otto knew the pair well enough to realize that they meant to carry out the plan. The idea was simple enough, and he wondered that someone had not tried it before. He was firmly resolved that none of the men on his watch would slip the place if he knew of it. Attempted escape meant one year more time to serve, with at least ten days in solitary confinement for good measure. He determined to prevent the getaway and at the same time keep the prison authorities in ignorance

of the affair. He was busy fussing with a feed pump when Connie and Shorty came through the engine room, a length of pipe on their shoulders.

"Headin' for the tunnel, Dutch," Connie growled in passing. "It's 9:30 now. Maybe we won't kill this job by 10:30. Tunnel's pretty hot yet. We'll eat when we come out." Otto watched them pass out into the yard and off in the direction of the big top.

At 10:30 p. m. as usual, the power plant force went to supper. Otto entered the main door of the dining room. Instead of seating himself at the long table he made a plausible excuse and passed out into the kitchen. He slipped out a side door, and by dodging behind the hospital building and bake shop was able to get back to the power plant unnoticed. He glanced at the clock. It was already past 10:30. He must work fast. He hurried into the ice plant. The ammonia pump was working smoothly, and from a pet cock on the pump cylinder he drew a quart of ammonia. His eyes filled with water, and nose smarted as though on fire. He hurried out in the open and around to the sewer manhole cap beside the boiler room and emptied the liquid into the sewer, quietly replacing the cover.

There was nothing to do but await results. He knew that there was a slight draft in the sewer in the direction of the larger sewer. It might be five minutes before the ammonia fumes filled the sewer. If they had not already sawed through the bars, he knew that no human being could stand those fumes for any length of time.

Five minutes passed. Ten minutes. He peered out into the yard and across to the mess hall where a faint clatter of dishes signalized that the meal was about over. The men would be returning soon. His plan had failed.

He had stood by and foolishly let two prisoners escape on his watch. He might be put in solitary for that. At that moment the captain of guards came into view from around the corner of the boiler room. Otto felt like crawling into the sewer after the two escaped men.

"I say, Shumann," roared the thick-necked captain, "Where in hell are those two pipefitters Ain't in the mess hall. Ain't in the tunnel. C'mon now. Where are they? I got to locate them."

Otto was on the point of confessing the whole miserable business when the night crew returned from the mess hall. At the end of the line came Connie and Shorty. Otto pointed a jubilant finger at the two men. "Dere cap, is der two. Vy all der fuss?"

"Well?" glowered the captain as the two pipefitters came up. "Where have you been?"

"In the tunnel, sir," stuttered Shorty. "Fixin' a steam line. Thought we'd finish before comin' out."

The captain softened perceptibly. "Go over to the mess hall then and get your chow," he concluded.

"Thanks captain, we don't feel like eatin anything," Connie replied. "Lost our appetities. Too hot in that tunnel I guess."

Otto detected a faint odor of ammonia as the two would-be getaways passed. Out of the corner of his eye Connie squinted suspiciously at Otto as he passed on toward the cell house, but said nothing.

When the iron door clanged shut behind the two, Otto heaved a deep sigh of relief. From afar, the moaning whistle of a freight train pulling out to parts unknown, came faintly through the night air.

"Dere's der train, boys. She goes in any minute. Better hurry, Chass."

First Part of Moffat Tunnel Completed

BY REMOTE CONTROL, President Coolidge set off the blast which broke down the last barrier between the two bores of the preliminary work of the Moffat Tunnel, on Friday night, February 18, at 8:10 o'clock mountain standard time. Elaborate ceremonies in honor of the event were staged in Denver, conducted by Governor Adams of Colorado, and broadcast from radio station KOA of the General Electric Co. in that city.

The preliminary tunnel completed by this blast is 8 ft. in diameter and has served as an exploration tube and, later, will be used as an aqueduct to carry water from the high western plateau into Denver. Following closely on its heels is the construction work on the main tunnel, whose dimensions will be 24 ft. by 16 ft.

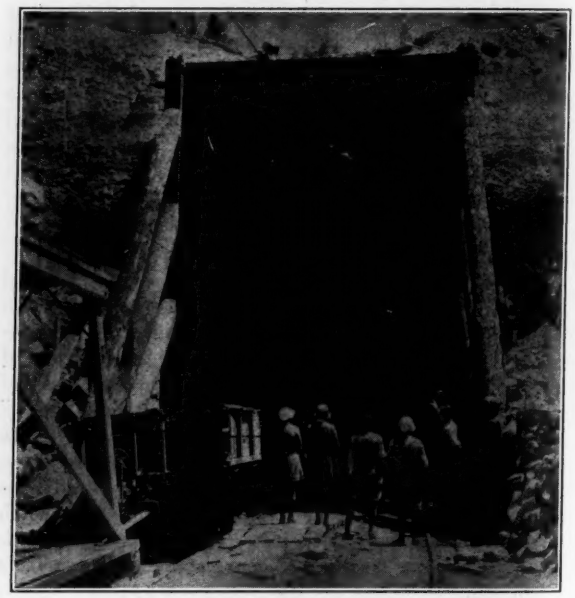


FIG. 1. WEST PORTAL, MOFFAT TUNNEL, SHOWING METHOD OF TIMBERING

The Moffat tunnel, boring under the Continental Divide, will be 6.04 mi. long, the second longest tunnel in the world. It will be three miles shorter than that of St. Gothard under the Alps. It will open the western slope of the Rocky Mountains to all-year traffic, connecting in the west with Moffat's original railroad below the snow blockage line. On the eastern side it enters the mountain at a point about 50 mi. from Denver at an elevation of 9198 ft. Near the middle of the tunnel the elevation is 9222 ft.—a peak or high point to allow ready drainage. With the utilization of the proposed Dotsero cutoff, a 41-mi. branch railroad to be built from the west portal of the tunnel, the distance from Glenwood Springs, on the west slope, to Denver, will be reduced from 343 to 173 mi. In addition, the tunnel will eliminate 23 mi. of the railroad over Corona Pass, practically all of which is above timber line on a 4 per cent grade; it will cut down the elevation by 2406 ft., and reduce grades to 2 per cent.

In addition to its two railroad tracks, the Moffat tunnel will be traversed by telephone, telegraph and

power cables important to the life of the Rocky Mountain section. Automobiles will be carried through on flat cars, allowing motorists to make the trip over the Divide at all seasons. The railroad in the tunnel will be electrified, electric locomotives hauling the trains. Steam locomotives will have their fires banked and will be hauled through with the trains.

Tunnel construction work was started in October, 1923, under the direction of the Moffat Tunnel Commission and Tunnel District of Colorado. About 4000 hp. in electric motors has been and is being used in the work; motor generators and motor-driven compressors furnish light and power for excavation and construction; electric locomotives provide haulage facilities and

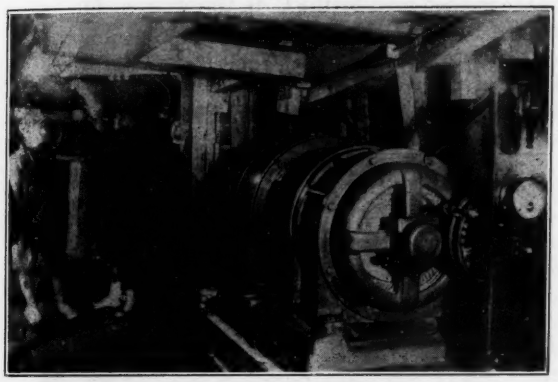


FIG. 2. MOTOR-GENERATOR SET FOR OPERATING LOCOMOTIVES IN TUNNEL

transformers supply power at proper voltages from electric transmission lines. Nearly all the electrical equipment for the work was furnished by the General Electric Co.

Mine Mouth Power Plants Have Limitations

MARKET, WATER SUPPLY AND FUEL RESERVE ARE PRINCIPAL FACTORS AFFECTING PLANT LOCATION

WHETHER a central station should be located at the mouth of a mine or at a distance from the coal fields, said George A. Orrok in his address at the International Conference on Bituminous Coal, held at Carnegie Institute of Technology, depends mainly upon three factors. The first of these factors may be considered under the head of markets. Nearness to a market implies short transmissions and small losses, therefore smaller investment and operating cost.

Adequate water supply comes next. Ferranti considers this factor of prime importance since from 500 to 1000 t. of water are required for each ton of coal burned in the station, if good thermal economy is to be secured. If the supply of water is not adequate, spray ponds or cooling towers must be used, the installation must be larger due to loss of vacuum and the fuel used must of necessity be much greater.

Next to markets and water supply comes a certain and adequate fuel supply without which no satisfactory production of power is possible. Water supply figures are well known, transmission costs are comparatively stable, but the quality and price of fuel at any given plant has varied over a wide range in the past in any given period of years. What it will do in the future no man can tell. Thus we have a problem involving the summation of three factors in which the cost of transmission to markets, the cost of the supply of water and the cost of fuel must be so chosen as to insure a minimum delivery cost at the point of use.

TRANSMISSION COSTS

Transmission costs are well known and have been published so often that they may be said to have been standardized. The most recent study is by Col. Kelly in a report of the Federal Power Commission to Secretary Hoover. Some of his curves have been reproduced in the report of the North Eastern Super Power Committee, brought out a few months ago. It will be noted that his figures in the usual range of load factors vary between 1½ mills at 100 mi. distance to about 3 mills at 300 mi. distance. Transmission costs, however, should be avoided and wherever possible the station should be located near the center of distribution.

WATER SUPPLY

The flow of our larger rivers has been measured by the Water Supply Division of the Geological Survey and its publications enable us to determine the available supply of water of most of our rivers and creeks. Wherever possible the station should be located where reasonably cool water in adequate quantity is available, either on a river with a good average flow or else on a large lake or arm of the sea. This reduces the water cost usually to its lowest limits. When this is not possible, spray ponds or a cooling tower installation have been used.

Spray ponds require a large area for a small effect; cooling towers are usually a much better investment than the spray ponds, especially when larger amounts of power are being considered, but no station using cooling towers to cool the condensing water has done better than about 25,000 B.t.u. per kw-hr., over a year, even in Europe where the mean and annual temperature is considerably lower than in the United States. The loss of power involved is also considerable and may be as large as 10 to 15 per cent. Notwithstanding this, there have been many installations using the cooling tower system with fairly good success in places where the water supply is small and the mean annual rainfall low.

The space occupied for the cooling towers is nearly, if not quite as large as the station itself and the pumping heads are considerable. When we remember that in this country we have at least 24 power stations which are running on less than 20,000 B.t.u. per kw-hr., over a year, and some on as low as 15,000 B.t.u., it will be seen that artificial cooling methods should be avoided wherever possible.

POWDERED COAL INFLUENCES

Locating the central station at the mine mouth reduces coal cost to the minimum. With powdered coal firing it has become possible to obtain good efficiency with the poorer grades of fuel and a reasonable efficiency can be obtained with waste low grade fuel. It will readily be seen that the poorer the coal, i.e., the larger the percentage of ash, water and sulphur, the larger

the freight fraction becomes and a point soon is reached where the fuel cannot stand transportation charges and must be utilized at the mine or be wasted. Such is the case at Golpa, Fortuna, and Hirschfeld, in Germany, where the coal carries 55 per cent of water and less than 40 per cent of combustibles.

Proximity to Water Prime Requisite

If sufficient water is present in proximity to the mine as at Toronto or Beech Bottom, good vacuums can be obtained and the water cost may be reduced to a minimum also. Where the market is close by as in the stations near Pittsburgh, Springdale and Colfax, the third criterion, transmission cost to markets, is also satisfied and the minimum cost at the point of use is obtained.

Under the price conditions prevailing in the United States, it has become increasingly evident that no cooling tower central station can be commercially successful in competition with our cheaper transmission costs. This limits the mine mouth plants to those locations where condensing water may be had in abundance and transmission costs are cheaper than coal freights to a point on a good water supply nearer the market. Col. Kelly, in his report to Secretary Hoover, quoted above, stated: "When, in addition, the difficulties incident to high-tension transmission are considered, it is safe to say that the local plant will be favored except when a material saving can be shown. Under present conditions it is not likely that power from plants at the mine will be transmitted to distances greater than 200 mi." At present writing and with his figures revised to 1926 conditions, his 200 mi. is probably the maximum distance at which mine mouth power may be sent and the economical distance may be much shorter. Mine mouth locations are thus limited to those coal fields on rivers or lakes of considerable size and where the markets are within say 100 mi. from the point of supply.

Influence of Low Temperature Distillation

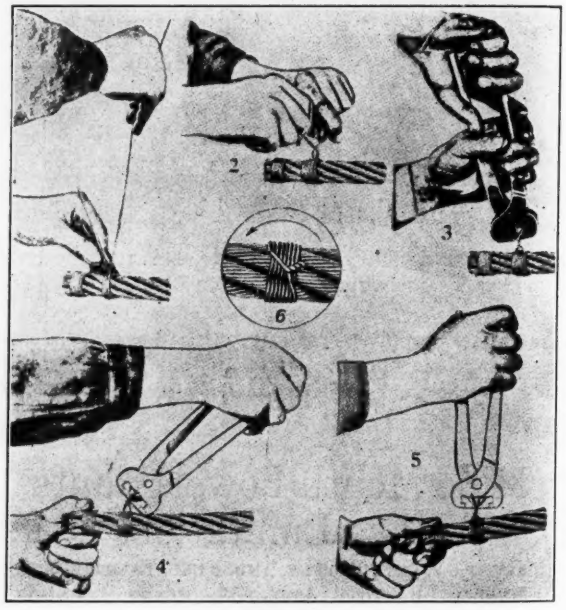
No discussion of this kind would be complete without considering the many suggestions and much experimental work which has been done along the lines of low temperature distillation in its connection with the generation of power. The only power plant in this country where this has taken definite form, however, is the new installation of the Milwaukee Railway Light & Power Co., which is just starting up. The combination of a distillation system turning out a good fuel for a steam generation as a main product and supplying valuable by-products which can be sold, is an ideal greatly to be desired. The difficulties in the way of developing a low-temperature distillation system, a continuous 100-per cent load factor process, in connection with the generation of power which is at the best a fluctuating 50-per cent factor operation, are considerable, while the markets for by-products are in a most unsettled condition at the present time.

With tank car gasoline quoted at 13 cents, Pennsylvania crude at $3.20 per bbl., ammonium sulphate at $50, and the tar distillation companies working on about 4½ cents to 5 cents per gal., it does not seem possible in this country to make out a commercial case at the present time. In view, however, of the restricted supplies and the enlarging use of oil products, it is only a matter of time when the supply will not be equal to the demand and the value of these products will rise to a point where commercial economies may be secured. The experimental work which is under way will be of great value in determining the course of design in the future, and it may well be that these developments may be deciding factors in the location of generating plants in certain coal fields.

Seizing Wire Rope

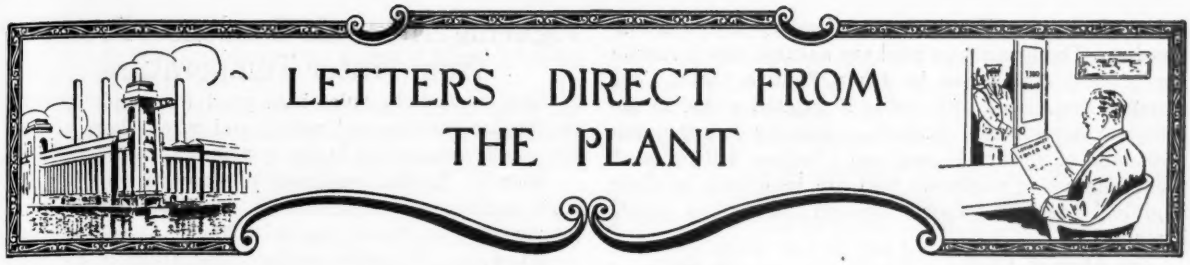
WIRE rope and cable, if not properly attended to, may cause considerable trouble from unlaying, and a recent issue of the Sauerman News gives details of the method used by the U. S. Government for treating rope of this kind.

At least three seizings should be used. Six or eight turns of the seizing wire should be used and the coils kept together with considerable tension on the wire, as in Fig. 1. The two ends of the wire should then be twisted together counter-crosswise, so that the twisted portion of the wire is near the middle of the several turns. With cutters the twist should then be tightened just enough to take up the slack. By twisting and tightening alternately as in Fig. 4 several times, the slack can be taken out of the wire and the ends cut off. The twist should then be pounded flat against the rope as in Fig. 6 and the ends turned under to avoid a dangerous projection.



METHOD USED BY U. S. GOVERNMENT TO PREVENT UNLAYING OF WIRE ROPE AND CABLE

United States Senator Arthur R. Gould of Maine has started construction of the Quebec Extension Railway, which is expected to open up for development vast hydro-power areas in Northern Maine and Quebec. Construction of the railroad will require 2 yr. and cost approximately $5,000,000. It will extend 111 mi. through virgin forest.



Receiver Pressures for Compound Engines

IN THE November 1 issue, there was a rather lengthy letter dealing with the subject of receiver pressures for compound engines, but I can hardly agree with Mr. Cooney in his conclusion that a ratio of 0.8 "is nearly enough a balance for practical purposes." A good engineer will set his receiver pressure that close by merely noting the running and vibration of the engine, and there is no reason why he should go through such lengthy and laborious calculations to arrive at an approximate result.

Why is it necessary to base calculations on approximations? Approximations and formulas have, of course, a very definite place in engineering work and, when used by experienced and capable engineers familiar with their limitations in applications, there can be no possible objection to them. Calculations which must be modified by coefficients should be based upon solid foundations or fundamentals familiar to the user. It is no more complicated as a rule and gives one something definite from which to work. In this case it is particularly true, because the development of suitable formulas is simple and logical.

Starting with a simple rectangular cycle as in Fig. 1, the proper receiver pressure to give a balanced load between the two cylinders would be found from Equation 1 which can be changed to Equation 2. Equation 1 is, of course, based on the formula: hp. = PLAN ÷ 33,000. 33,000, L and N cancel out being the same for both cylinders, while the area ratio of the two cylinders is given by the ratio of the squares of the cylinder diameters and is called R.

In an engine with cutoff, however, things are not so simple although Equation 2 will give a good approximation of the proper receiver pressure and is sometimes used by rule of thumb engineers. In a simple engine, the card, as in Fig. 2, is made up of two parts, areas I and II. Obviously, the area of the rectangle I is PXV. The area II is given by Equation 4, the area under a section of a hyperbolic curve. Combining the two and simplifying gives Equation 5, the mean pressure over the entire forward stroke. The m.e.p. will, therefore, be the pressure minus the average back pressure as in Equation 6.

This, then, brings us into the compound engine, Fig. 3 and Equations 7 and 8, the derivation of which is easily seen. The value r as used in Equation 7 is determined by the high pressure cutoff; thus, for one-third cutoff, r equals 3. In Equation 8, the value R is the cylinder ratio because the expansion line in the cylinder is independent of the low pressure cutoff. As a rule it is difficult for new engineers to understand that the low pressure cutoff does not affect the expansion line.

Having determined the m.e.p. for both cylinders, it is possible to solve for the receiver pressure which will give equal loads on both sides. Following the method used in Equation 1, we get Equation 9, and following through Equation 10.

FIG. 1

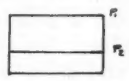
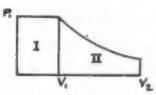


FIG. 2



$$(P_1 - P_2)d_1^2 = P_2 d_2^2 \quad \text{---------- (1)}$$

$$\frac{P_1 d_1^2}{d_2^2} - \frac{P_2 d_2^2}{d_2^2} = P_2$$

$$R = \left(\frac{d_1}{d_2}\right)^2$$

$$\text{so } \frac{P_1}{R} - \frac{P_2}{R} = P_2$$

$$P_2 = \frac{P_1}{R+1} \quad \text{---------- (2)}$$

$$\text{Area I} = PV_1 \quad (3)$$

$$\text{Area II} = PV_1 \log_e \frac{V_2}{V_1} = PV_1 \log r \quad (4)$$

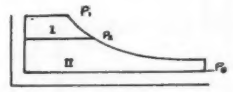
$$\text{Total Area} = PV_1 + PV_1 \log r = PV_1(1+\log r)$$

$$\text{Mean Press} = \frac{\text{Area}}{V_2} = \frac{PV_1(1+\log r)}{V_2}$$

$$= \frac{P(1+\log r)}{r} \quad (5)$$

$$\text{M.E.P.} = \frac{P(1+\log r)}{r} - P_2 \quad (6)$$

FIG. 3



$$\text{M.E.}P_1 = \frac{P(1+\log r)}{r} - P_2 \quad (7)$$

$$\text{M.E.}P_2 = \frac{P_2(1+\log R)}{R} - P_3 \quad (8)$$

$$\overline{(\text{M.E.}P_1)}d_1^2 = \overline{\text{M.E.}P_2}\, d_2^2 \quad (9)$$

Substituting (7) and (8)

$$\left[\frac{P(1+\log r)}{r} - P_2\right] = R\left[P_2\frac{(1+\log R)}{R} - P_3\right]$$

$$P(1+\log r) - rP_2 = P_2(1+\log R) - RP_3$$

$$P_2(1+\log R) + P_2 = P(1+\log r) + RP_3$$

$$P_2 = \frac{P(1+\log r) + RP_3}{2+\log R} \quad (10)$$

Example:

$$P = \frac{165(1+1.0986) + 5\times 3}{2+1.6094} = 36.3$$

DEVELOPMENT OF FORMULA FOR CALCULATING RECEIVER PRESSURES FOR COMPOUND ENGINES

Using the same engine as Mr. Cooney, i.e., 24½ by 54¼ by 36 with one-third cutoff, 165 lb. absolute pressure and a back pressure of 3 lb., we can substitute the various values. P equals 165; r equals 3; R equals 5; P_3 equals 3 and solving for P_2, gives about 36.3 lb. absolute. This equation has the advantage of not being an approximation. It considers cylinder ratio, cutoff and back pressure. If desirable, a diagram factor can be used and other refinements added to get it as close as desired. For instance, considering a 5 per cent clearance in the high pressure cylinder with one-third cutoff would change the value of r from 100 ÷ 33.3 to 105 ÷ 38.3 or from 3 to 2.86.

If an engineer is capable, using an approximation intelligently, he should be curious enough to want to know why he is using an approximation rather than an exact expression. When one is using a formula, it is just as easy to use one that is exact. Equation 10 is applicable to all pressures, condensing or non-condensing and therefore has the advantage over approximate

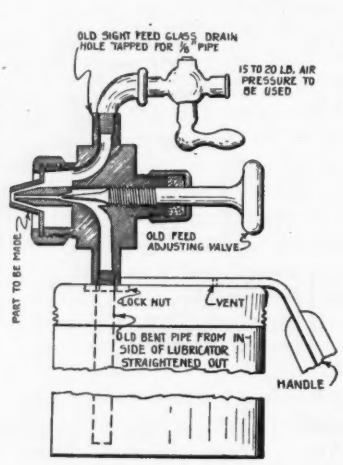
rules which are difficult for condensing and non-condensing. The logarithms used are natural logs (common log × 2.3) which can be taken from a table. The formula itself is of little value if printed alone, so the complete development is given. Nothing but the simplest kind of algebra is used and I believe will prove of great interest to engineers who are interested in their engines. They can follow it through and see how simple it really is.

Los Angeles, Calif. G. REED.

Home-Made Paint Gun

THE USEFULNESS of a paint gun around the power plant is not appreciated until you buy or build one and find the many difficult brush jobs it will do, in only a fraction of the time required with a brush.

I was sold on the idea some years ago. An armature winder had completed a job of putting a new set of armature coils in a large turbo-alternator. He made a paint gun out of ⅛-in. pipe fittings and short lengths


OLD SIGHT FEED GLASS DRAIN HOLE TAPPED FOR ⅛" PIPE
15 TO 20 LB. AIR PRESSURE TO BE USED
OLD FEED ADJUSTING VALVE
PART TO BE MADE
LOCK NUT
VENT
OLD BENT PIPE FROM INSIDE OF LUBRICATOR STRAIGHTENED OUT
HANDLE

DETAILS OF HOME-MADE PAINT GUN

of pipe with a couple of cocks to adjust the air and paint flow. It was a simple siphon but it did the paint job in about 20 min., and covered the job as perfectly as if it had been dipped.

It is good practice to take motors and generators out of service every 2 yr. and disassemble and thoroughly clean, and apply a light coat of paint. The regular weekly or monthly blowings will be more efficient because dust can be blown from the smooth, painted windings more readily than from the usual film of oil and dust that covers windings and can not be removed by blowing.

The cross-sectional sketch, herewith, shows a home-made paint gun, the parts for which can usually be found lying around, with the exception of the screwed cover can. The head, as is easily seen from the drawing, is the bottom fitting of the sight feed bracket of an old hydrostatic lubricator. The plate that makes up the nozzle and is clamped under the old sight glass packing nut is the only addition to the head. The ease with which the gun may be taken apart and cleaned after use is obvious.

Sheboygan, Wis. G. J. SNOWDEN.

Figuring Ammonia Condenser Pressure from Water Temperature

THE FOLLOWING rules hold good for ample amount condensing surface and water, and when there are no non-condensable gases in the system.

Rule I. To find condenser pressure in pounds gage, from initial water temperature, multiply initial water temperature by 2 and then add 20.

Example. If initial water temperature is 60 deg., what should the condenser pressure be?

Cond. press. = (60 × 2) + 20 = 140 lb. gage.

Rule II. To find condenser pressure in pounds gage, from final water temperature, multiply final water temperature by 2 1/3 and then subtract 25.

Example. If final water temperature is 90 deg., what should its condenser pressure be?

Cond. press. = (90 × 2 1/3) — 25 = 185 lb. gage.

Chicago, Ill. W. H. MOTZ.

Routine of Checking Speed-Limiting Devices

I NOTED in a recent issue of Power Plant Engineering a comment by J. J. McDougall on the necessity for observing the safety precautions on high-speed machines and thought that perhaps the method which is followed in our plant might be of interest to readers.

We have an industrial plant of several thousand horsepower, consisting of small turbines and reciprocating engines driving the plant auxiliaries, and four main units, consisting of two reciprocating engines, one of 200 hp. and one of 1600 hp., and two turbines of 500 and 2000 kw. capacity. The 200-hp. unit runs at 225 r.p.m. and the 1600-hp. at 71½ r.p.m., and both are equipped with over-speed devices which can be tripped automatically in case of over speed, or manually from any of the stations provided for the purpose.

The two main turbines run at 3600 r.p.m. and are equipped with the usual device attached to the end of the shaft which trips the throttle in case of over speed.

Four of the small high-speed turbines which drive the circulating pumps are equipped with over-speed devices furnished by the builders, the remainder of the auxiliaries are not equipped with over-speed devices, dependence being placed on the regular constant speed governor to hold the speed within safe limits.

Two comparatively low speed auxiliaries are also equipped with over-speed devices installed by the builders.

The 2000-kw. turbine runs 8¾ hr. each day except Saturday and Sunday. Saturday's run is 4¼ hr. and on Sunday it is idle. The throttle on this machine is tripped by hand twice each day, which checks the throttle to insure that it is not sticking in the packing, and the no load speed is taken by means of a hand tachometer every night just before the throttle is tripped and at the end of the Saturday run, the turbine is speeded up by holding the governor until the automatic tripping device operates to close the throttle; a hand tachometer is applied to the shaft during this operation and the tripping speed is carefully noted; this method gives a daily check on the throttle and a weekly check on the combined over speed device and throttle.

We have a special form covering a period of one

month and the no-load speeds as observed by the tachometer are recorded daily and the over speed tripping point is recorded weekly.

Full load speed of pumps and exciters is taken one week and the no-load and trip speeds of the same units the following week, by a hand tachometer and these speeds are recorded on the monthly form.

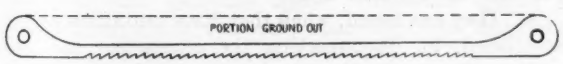
On the 200-hp. unit, the over-speed device is tripped by hand daily, and the governor is blocked and the automatic over-speed device is tested monthly; both events being recorded on the monthly sheet.

The 1600-hp. engine is equipped with the regular Corliss valve safety cams on the governor ring as well as the over-speed device. The safety cams, which prevent the hooks from opening the valves when the governor is at both the high and low extremes of travel, are tested for low governor travel only once each week, the automatic stop valve is tripped by hand once each week and the over-speed device is checked monthly by allowing the engine to run over speed until it trips, a hand tachometer being held on the shaft of the speed-limiting device to note at what speed the device operates and also to prevent over speed in case the automatic device fails to operate. The result of this test is also recorded on the special sheet with the other speeds. The speed checking is done by the regular crew and requires only a few seconds each day and any irregularity in the operation of the various devices is noted and repaired before serious trouble develops.

Plymouth, Mass. C. B. HUDSON.

Hack Saw Blade Useful for Scroll Saw Work

BY GRINDING down the back of an ordinary hack saw blade, as shown in illustration herewith, it may be conveniently used in scroll saw work, in which case it



GRINDING DOWN BACK OF BLADE PERMITS USE FOR SMALL CURVED WORK

should be placed in the frame in a position reversed to that which is usually used in ordinary hack saws, so that the saw is pulled during the cutting stroke, as is usual with scroll saws.

Boulder, Colo. C. E. CUMMINGS.

Lubrication of Marine Steam Engines

"MARINE STEAM Cylinders Have No Lubrication," page 1177, November 1 issue of Power Plant Engineering, interests me, because in my younger days I had "followed the sea" as a marine engineer and had been in ships that used no lubricant for the steam cylinders other than that provided by swabbing the piston rods and valve stems, which by the way is very little. Also, I had been in ships that did use lubrication for the internal parts of the engine, independent of that obtained from swabbing piston rods and valve stems.

From these experiences, I must say that, all things considered, I favor lubricating the internal parts of any steam engine with oil, not water. Of course it must be the right kind of oil; that is, an oil that meets all the conditions of operation of the engine such as pressures, temperatures, steam quality, superheated, dry or wet steam. As well as this, the method by which the oil is introduced, and the place where it is introduced, have an important bearing on the matter.

The statements contained in both question and answer in the page to which I refer are true. But I doubt if the practice followed, as stated in the answer, is correct. We know that oil is a better lubricant than water, for water has not the body to effect lubrication in the highest degree. If water were as satisfactory a lubricant as oil, then it would serve the bearings and all the external parts of the engine as well as it is presumed to serve the internal parts of the engine.

Now, the main reason that oil is not generally used for the internal parts of marine steam engines is not because water of condensation is entirely satisfactory in the opinion of those who depend upon it, but rather because of the possibility of the spent cylinder oil getting into the boilers and causing damage there. Present day marine superintendents and sea-going chief engineers have told me quite recently that if it were not for the fear of oil getting into the boilers, there would be no question about using cylinder oil for the pistons and valves.

There are two main reasons why oil should be used for internal lubrication of steam engines—either stationary or marine—namely:

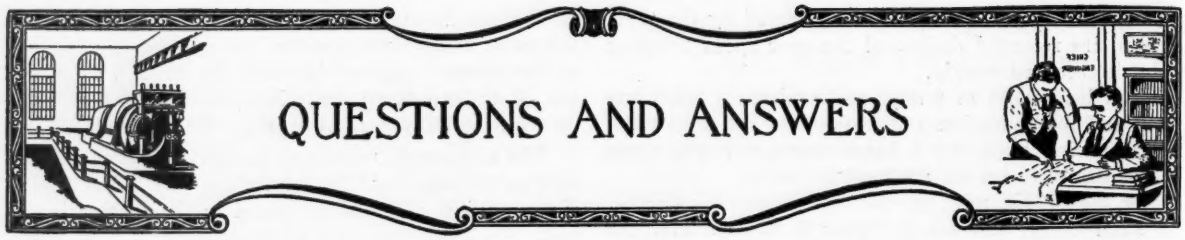
1. Oil of suitable character affords better lubrication than can water, therefore frictional resistance to the moving parts is lowered and power is saved.

2. Oil provides a piston seal that is more durable than water, to prevent the possible "blow-by" of the steam. Here again power is saved. Power saved is shown in lessened cost of operation over a reasonable period of time. Also, oil between the valve parts and their respective seats will prevent the leakage of steam past the valve to a higher degree than can water. Therefore, as a lubricant and as a seal, aside from any other consideration, there can be no doubt as to the superiority of oil over water for the purposes specified.

In times past there has been considerable trouble with oil getting into the boilers in marine practice; but now, with controlled feed of oil to the cylinders by means of mechanical force feed lubricators, and the use of an oil suitable to the conditions encountered in actual operation, there should be no fear of trouble from oil getting into the boilers. Besides, there are several types of grease extractors and feed water filters to be obtained that prevent the entry of spent cylinder oil into the boilers. In the first place, with a controlled feed, there is little oil in any given period gets into the cylinders, and in the second place, what little might get past filters and into boilers would be negligible.

As a matter of fact, there are ships which employ cylinder oil and which are equipped with the apparatus to which I have just referred, and they have no trouble from using oil. That all steamships do not use oil for the internal lubrication of their engines is a pity, for efficiency and economy, both, are affected by the use of oil properly selected and correctly applied and taken care of. The saving effected over a period of time outweighs the cost of the lubricant.

Brooklyn, N. Y. CHARLES J. MASON.

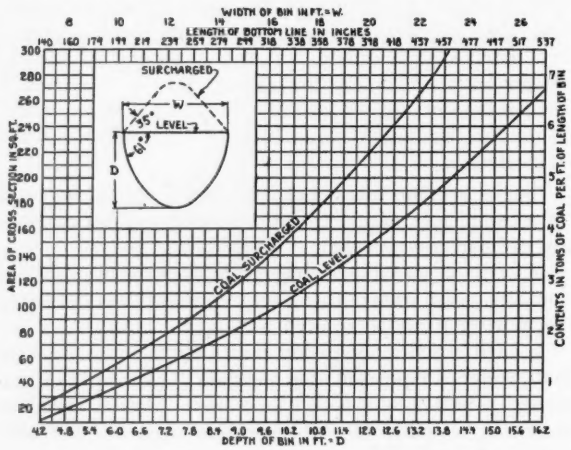


QUESTIONS AND ANSWERS

Design of Suspension Bin

PLEASE LET ME know the formulas for designing a suspension bin, particularly for calculating the valley angle of a bin with sloping sides. F. C.

A. In the design shown below, the bin is of all steel structure with sloping sides and rounded bottom. The sides are slightly curved; the shape of the bottom line of the bin approximates a catenary or parabolic curve.



SHOWING RELATION BETWEEN DIMENSIONS OF BINS, CAPACITIES AND LENGTH OF BOTTOM CONTOUR BASED UPON A BIN DEPTH OF 0.6 THE WIDTH

The approximate angle between the side and the top is 61 deg. as shown in illustration. The limiting factor in the determination of this angle is the angle of repose of any kind of coal that may be placed in the bin.

In designing a bin, the required size and location must first be established. It should hold at least enough coal to carry the plant during possible interruptions in transportation or repairs to the coal-handling machinery. Beyond this, the capacity that would be provided to take care of possible mining and railroad strikes must be left to the engineer's judgment or to the owner's willingness or ability to spend money for what may be regarded as an insurance expense.

If the bin is directly in front of the boilers, the bottom should be high enough from the floor to avoid interference when the boiler tubes are cleaned or replaced. The bin should not obstruct the light and the spouts to the stokers should always be less than 40 deg. from the vertical. If the bin is at one end of the boiler house, the height to its lowest point is determined by the traveling hopper or crane which takes coal from the bin and distributes it to the stokers.

To secure maximum capacity for a given boiler room, the bin is made continuous for the entire length occupied by the boilers. Continuous bins are either hung from the roof trusses or supported by the building columns. The bottom should always be sloped to assist the coal toward the spouts and to lessen the risk of coal catching on fire in deep bins in places where it may lie dead.

Suspension bins are light in weight per ton of contents. The steel sides are in direct tension. Illustration herewith shows the relations between the dimensions of such bins and their capacities in tons of coal, based upon a bin depth of 0.6 the width and with level filling or a surcharge at a slope of 35 deg. The length of the bottom line for various depths is also shown.

Steam Problems

WILL YOU PLEASE answer the following questions:

1. What are the striking points of an engine, how do you find them and what is value of knowing them?

2. What device is used in a return tubular boiler to prevent bagging?

3. Why is a receiver used on a cross-compound engine?

4. What is the correct way to find the clearance in an engine cylinder?

5. What is the proper way to test the coils of a closed heater or test the heater for leakage? W. L. D.

A. 1a. Striking points are marks made on the guide which, when a reference mark on the crosshead coincides with them, indicate when the piston is in contact with the cylinder head.

b. They are found, when they have not already been established, by disconnecting the connecting rod and pushing the crosshead and piston until the latter is in contact with the head at that end of the cylinder, then making a mark on the guide to correspond with a reference mark previously made on the crosshead. The striking point at the other end of the cylinder is obtained in a similar manner.

c. They are of value in assuring adequate mechanical clearance at the ends of the stroke.

2. Bagging of a boiler plate is caused by overheating, generally due to scale or other deposits accumulating to such an extent that water is prevented from coming in contact with the plate. Under the influence of the accumulated local heat the plate becomes soft at this section and easily yields to the pressure acting upon it, thereby forming a bag. To avoid this, accumulation of scale is prevented by removing the materials that would otherwise be precipitated during the heating of the water or by changing these materials into compositions that will not be precipitated. Such devices include water softening and treating apparatus, skimmers, blow-off devices, steam and water purifiers, and the like.

3. In the cross-compound engine, cranks are usually set 90 deg. apart and the cylinders do not work simultaneously; steam exhausted from the high-pressure cylinder is held in the receiver before being admitted to the low-pressure cylinder. For this reason a receiver

between the two cylinders is necessary in order that the exhaust pressure may not build up on the high pressure piston before admission to the low-pressure cylinder.

It is not necessary to have a receiver with a tandem-compound engine, for as the steam is exhausted from the high-pressure cylinder it immediately goes into the low-pressure cylinder.

4. This question was answered on page 268 of the Feb. 15, 1927, issue.

In the determination of the clearance volume by the water displacement method, leakage may be accounted for in the following manner: Set the engine exactly on the center, with the piston at the end of the cylinder where the clearance is to be determined. From a quantity of water previously weighed pour enough into the clearance space by means of a funnel through some available opening, such as may be obtained by removing a steam valve in a horizontal four-valve cylinder, or through the holes for indicator cocks, until the clearance space is completely filled. By weighing the water remaining, the amount necessary to fill the clearance space can be obtained and by making proper allowance for temperature the clearance volume may be calculated.

The percentage of clearance is then found by dividing the clearance volume thus found in cubic inches by the volume displaced by the piston in one stroke, also in cubic inches. Care should be taken to see whether the clearance space is so arranged that no air is retained when it is filled with water. If such pockets cannot be properly vented, this method will not give accurate results. When full, the gradual lowering of the water will show leakage by the valves or piston. Allow leakage to go on for a certain time, then from a quantity of water previously weighed pour enough into the clearance space to fill it up again, note the time it takes to do this, and weigh the water remaining after filling up the clearance space. Then the weight of water from which clearance space is to be calculated (W_1) can be determined as follows:

$$W_1 = W - \frac{wT}{t + t_1}$$

where W = weight of water filled into clearance space, first time.
T = time to fill clearance space.
t = time allowed for leakage.
w = weight of water for filling space up again after leakage.
t_1 = time required to fill clearance space again.

This method will give the proper correction to be subtracted if the leakage is not very great. If the leakage is too great and the object of the test will allow it, the valves and the piston rings must be put in proper condition.

When the above method is used it is not necessary to pack the piston in order to avoid leakage.

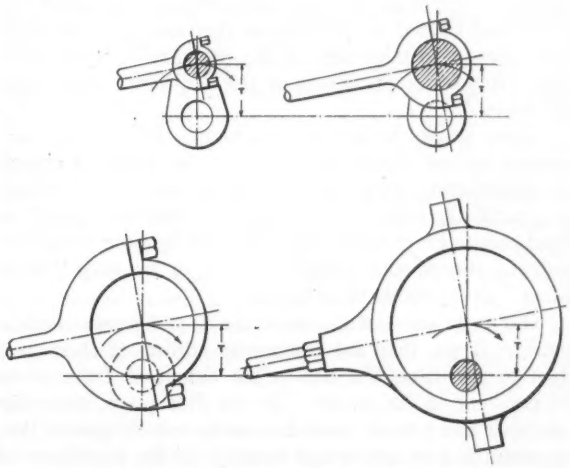
5. Shut off the steam, open the drain cocks and admit the cooling water under a pressure of approximately twice that normally used. If leakage occurs, water will be forced into the steam pipes and may be collected at the drain. To find the exact point at which a leak occurs, the heads should be removed, the pipes painted with a soap solution and steam pressure admitted into the coils.

Eccentrics and Cranks

In an Ohio examination for an engineer's license, the difference between the eccentric and crank of an engine was asked. I cannot find a correc answer to this question. Can you give it to me? H. B. S.

A. An eccentric is essentially a center crank, the radius of whose crankpin is larger than the throw of the "crank." It is so made to avoid weakening the shaft at the point from which short stroke reciprocating motion is to be derived.

In most engines an eccentric gives the motion to the valve gear; the engine crank changes the reciprocating motion of the piston into the rotary motion of the flywheel.



SHOWING EQUIVALENCE OF CRANK AND ECCENTRIC

To illustrate the relation that exists between an ordinary crank and an eccentric, assume, for example, a crank such as shown in the illustrations in which "t" is the throw. If the crankpin is made larger while the other parts of the crank remain the same, the crank mechanism is not essentially altered; the motion which it would impart to a connecting rod is not changed.

If this process of enlarging the pin be continued until the pin has become large enough to surround the shaft, the crank arm as a separate member will have disappeared and become absorbed in the crankpin itself and an eccentric results. It is the exact equivalent of the original crank; its center, which is the center of the crankpin, revolves about the center line of the shaft in a circle with a radius "t" just as in the original mechanism.

Public service companies in New Jersey have upwards of $57,000,000 available this year for new construction, extensions and improvements throughout their territories. At the Kearny station of Public Service Elec. & Gas Co. about two-and-a-half million dollars will be used for the installation of the fifth unit of boilers to attain the maximum output planned for the first unit of this plant. About seven million dollars will be used for the building of new switching stations similar to those at Athenia and Trenton. Many new substations will be erected and about one million dollars will be spent for underground conduits in congested districts.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Advertising—A Manufacturing Operation

John Jones, Inc., sells $100,000 worth of goods, thereby making a profit of $20,000. From the resale value of the merchandise, $80,000 was paid out in wages, materials, machinery, transportation and so forth, leaving one-fourth as much available as surplus. One-half of the profits, or $10,000, goes for dividends, the remaining half for plant enlargement. Thus does the company pay out all it received, which was enough to buy the original output, but not enough to purchase the additional output or production increase now provided for. Money to take care of the increased output must come from other producers or the additional goods cannot be sold.

Using profits to increase production faster than consumers can get either the money or the desire to absorb the additional output has been in evidence as a policy in practically every line for years. That this policy is fundamentally unsound is evidenced by idle factories, reduced wages, and unemployment, in all save "boom times" or "periods of inflation."

Our most successful companies do not pursue such a policy. True, they are constantly adding to their production facilities, but not to the extent of from 40 to 80 per cent of the profits. In the first place, they pay adequate and proper stock dividends—an obligation that apparently does not weigh heavily on the shoulders of some managements. Second, a sizeable portion of the profits goes into research work—the scientific inquiry that seeks new markets, mechanical short cuts, reduced expenses and increased efficiency. Since 1898, the International Harvester Co. has maintained its Extension Department at a cost of one and one-half million dollars a year, the sole purpose being the betterment of the American farmer. There is nothing altruistic in the maintenance of such a department. The executives of that company merely realize that the better the farmer the more machines he will buy and use. From the research laboratories of the U. S. Steel Corporation, General Motors, American Cable Co., Standard Oil Co., and General Electric Co. have come improvements in design, manufacture and distribution that have been of far-reaching benefit to both producer and consumer. These improvements could not have been made had the companies been unwilling to spend money for scientific inquiry or had they been unappreciative of the value of research.

Reaction of the small manufacturer to this policy is too often: "Yes—that is all right—for them. They are large companies and have the money to spend. But we are small and need our money for more machinery and better facilities." To that reaction must come the answer: Few things, even machinery or increased facilities, are of greater value than the expansion of markets, or the development of methods for the utilization of by-products. Increased facilities can be little more than a liability, if the market has not been expanded to an extent that will justify the increased production.

A third policy that is consistently pursued by successful enterprises is the tenacious adherence to adequate advertising. With them, advertising is as basic as any manufacturing operation. They realize that to be successful sales must be made as well as products and that advertising is as essential a part of sales manufacture as machines are to product fabrication. In times of general business depression, selling is more difficult than producing. For that reason the more successful companies apply a portion of the production budget to the advertising appropriation in periods of depression, thereby giving increased, not decreased, energy to the sales manufacturing force. It is true that, in such times, the dictates of good judgment may indicate a change in physical makeup of the advertising but the company that looks farther ahead than the immediate future of a few months always increases advertising effort in times of slowing down of sales, so as to manufacture orders as well as products.

Man and His 50 Slaves

Of the ancient rulers, Solomon, Nero, Cleopatra and the numerous Pharaohs, not one, however powerful or however numerous his slaves, could command the little glass bulb no larger than one's fist from which the light of 150 candles could be made to emanate at the pressing of a button. The slaves of old might have been able to bring to their masters chests of jewels and precious stones but not one of them could bring a chest of tubes, grid-leaks, condensers, and rheostats, through which the music of the lyre or zither played on the opposite side of the Mediterranean could be caught, amplified and made audible to the master. Slaves of historic times could bring slow-moving donkeys and camels in almost any number but they were powerless to bring forth an aeroplane that could traverse the sandy wastes with one hundred times the speed and safety.

During the intervening years between James Pharaoh and Thomas Jefferson the social and economic status of all peoples remained on pretty much the same level. The graphic chart of humanity which dates back to the Paleolithic age reveals but slight advance up to the time Watt, Stephenson, Fulton and Faraday came on the scene. Since then the line of human progress has taken a sharp upward turn. It is true that gun powder and other far-reaching developments were brought about before the coming of the mechanical era but it is equally true that, up to a comparatively short time ago, houses were heated by great open hearths, lighted by candles and watered from a nearby well. Now, due to the mechanical and scientific advances brought about since 1800, we have come to a state where we will tolerate fireplaces, candles and germ-laden wells only when on fishing or hunting trips. Through the augmented use of mechanical power, everybody has been supplied everyday commonplaces that surpass the most extravagant luxuries of ancient kings.

In the manufacturing enterprises of the thirteen colonies there were less than 400,000 mechanical horsepower employed. In the 50 yr. that followed, this total was raised to 2,300,000 horsepower, whereas, during

the past 50 yr. it has advanced to a total exceeding 30,000,000. In the mining and quarrying industry alone, there is now employed more than 7,000,000 horsepower of mechanical energy. The estimated horsepower of the U. S. Navy is about 13,000,000, while private yachts and motorboats add to that marine power a total of 10,000,000 horsepower. Today, agriculture employs more than 28,000,000 mechanical horsepower in spite of the fact that there are only about 7,000,000 horses used; while conservative estimates place the total horsepower of our twenty million automobiles at 480,000,000. The grand total for all figures shows that more than 600,000,000 horsepower is now being employed by our 115,000,000 people, which means that every man, woman and child in the United States has available for use more than five mechanical horsepower. Since a man's personal power rates less than 1/10 of a horsepower, this is equivalent to more than 50 slaves for each U. S. citizen. No longer is it necessary for us to envy the "good fortune" of the rulers of old who had at their disposal a few serfs and human slaves. Each one of us has available the power of 50 such slaves, in mechanical form, which upon analysis, provides us with luxuries, conveniences, and so-thought necessities utterly beyond the bounds of possibility with human slaves.

By the way, who was it that said that "mechanical devices were usurping the God-given right of man to toil at human labor?"

"Please Send Representative"

Probably every manufacturer welcomes those words. Few manufacturers, however, do not at times feel them a burden, since they have learned that the request may have back of it something entirely different from a quotation on new equipment. Because this is true, everyone having need to see another company's representative should be specific and fully state the reason for the request, thus saving the sending company expense and assuring better and quicker service.

During the past 15 yr. more and more engineering firms have found it to be to their advantage to employ only qualified engineers as salesmen. Today sales staffs of dozens of industrial firms are made up of engineering school graduates with from 3 to 20 yr. practical experience. Such men, as salesmen, are expensive, but, in the interest of customer service and company profit, they have been found the most economical. The manufacturer of engineering equipment receiving a request to "please send representative" is, therefore, at a loss to know whether to send a sales engineer, a service engineer, electrician, mechanic, or whatnot. Amplifying the request to include more specific information would be mutually profitable.

It is possible to give needed information when such requests are made without involving obligation or supplying undue information. "Considering the installation of additional hoisting equipment" is a simple addition to the words "please send representative" yet their inclusion enables the manufacturer to save his own money and afford better service. "Not getting the percentage of CO_2 we believe we should have" tells a whole story in itself and upon its receipt the manufacturer knows just which man from his force to send. No one would think of asking a mill making several different grades of paper "What is your price for 20 t. of paper?" The same principle applies to requests for representatives, particularly where the companies involved are of an engineering character.

Time Lost

Tardiness and time lost are, in some plants, a cause of considerable loss. In many plants a few years ago and in some of today, the practice of penalizing a man a full quarter hour for every lost fraction thereof was employed. This negative measure for discouraging tardiness is now being discarded and the plan for paying bonuses, ranging upward from 2 per cent of the worker's earnings is being substituted. In the majority of cases the positive method has been far more resultful than the negative.

Instead of a monetary reward, some plants allow a day's vacation to every employe having a perfect record for attendance and punctuality during the month. In figuring these records, consideration should be given to the promptness displayed in getting to work as well as the actual clock record. Sometimes it is advisable to arrange a sliding scale of reward to encourage nearly perfect as well as 100 per cent records. If the bonus periods are too long, an employe who has, for some good reason, failed to qualify for the bonus or day's vacation for a particular period will be inclined to disregard his attendance and punctuality record for the remaining portion of the period, feeling that he has nothing to lose.

The value of a good foreman is perhaps nowhere more clearly evident than in tardiness and absence records. The foreman, being in direct contact with the men, is in the best possible position to effect reductions in these factors. Through him loyalty and interest can best be developed. Without employe loyalty and company interest no management can hope to minimize absence or effect a reduction in tardiness.

Progress Photography

During recent years, photography has advanced to an important place in industrial construction so that few large undertakings are completed without being accurately recorded as to various stages of construction. Such records are frequently bound into permanent files so as to identify dates and condition of or steps in the work for the purpose of waste elimination on future work of similar character and for reference in case of litigation.

Industrial photography is also proving a valuable aid in recording and transmitting information on shop methods, handling of materials and taking of inventories. A still photograph of a shop where work is constantly being shifted about for fabrication and assembling gives a means by which all units may be accurately counted and tabulated without interfering with the progress of the work. In large special work, too, labor saving kinks may be given permanent record which will be of great value, if the operation has to be repeated at some future time.

Such records cost but little and will almost invariably save many times their cost over a term of years. It is worth while to study their adaptation to construction, repair and operating work in the power plant.

EDITORIAL COMMENT

What Men Do in Emergencies

In spite of every precaution that can be taken, accidents will occur. It is not possible, of course, to eliminate every single possibility of trouble, because we cannot always predict the behavior of the various materials used in a power plant. Our large factors of safety, or rather factors of ignorance, protect us in many cases. But when something does go wrong, it is extremely fortunate if no lives are lost and it is even more fortunate if the operators, even though they are injured, still retain their presence of mind and not only do what they can to stop the trouble but also observe every detail of operation preceding and during the trouble.

Such a case is narrated in this issue by Robert Althaus. While supervising the warming up of a steam line, a severe water hammer occurred and a valve burst directly over him. Although badly scalded, Mr. Althaus was still able to make his way to the shutoff valve, which he closed. The important part of the whole occurrence is that during the excitement he observed every detail and was afterwards able to use this knowledge in discovering how the accident was caused and how a repetition of it could be prevented. As a narration of human emotions and behavior under stress of extreme danger, we commend Mr. Althaus' story to all power plant engineers.

Cost Accounting and the Power House

Taking the power plant of an industrial company from the non-productive to the profit-making class, is not a job for the engineer, the manager or the accountant alone, but it is a subject which demands, and is worthy of, the combined ability and attention of the three.

Without the assistance of the executive department, the engineer can do little to better his plant conditions and without the assistance of the accountant, or his methods, it is practically impossible for the engineer to put the matter up to the management in such a way as to justify his requests for the purpose of improvement.

In the public utility field, where the power generating department is the productive, rather than the non-productive branch of the organization, a matter of cost accounting is receiving no little attention. Overhead which in the old days was the carry-all for expenses which could not be placed definitely in the labor or material class, has been split up into its component parts, to facilitate attacking the problem of cost reduction in a systematic manner.

There is a growing tendency in industry to consider the power plant as a separate and distinct part of the organization, selling power on the same basis as it would be purchased from the outside. This places the chief engineer in the position of an executive, particularly so, if as in many cases, the profit or at least a share of the profit shown on the books by the power department is available for changes, the purchasing of equipment and improving the personnel.

Obviously a reduction below that which is considered normal operation may be considered as a profit. Fundamentally the engineer is responsible for these profits or possible cost reduction, although there is no reason why the management should not exercise the same degree of supervision over the power plant as is exercised over other departments in the organization.

As changes are made and the more obvious items of needless expense or poor organization are eliminated, it becomes more and more necessary to analyze the problem and look for refinements, each negligible in itself, but when taken together with many others, making considerable showing. This analysis is the cost accountant's business and, although he may often require technical assistance and advice in development of the system, he is the logical one to undertake the actual statistical work. The engineer who neglects to work with the accounting department is missing a valuable aid in the economical operation of his plant and moreover he is overlooking an opportunity to learn to speak the language of the executive department.

Power and Longevity

During the middle ages the average span of the human being was 22 yr., but this was increased to 50 yr. at the beginning of the present century, and during the last 25 yr., the human life has added eight more years to its span, making the life expectancy in the United States now more than 58 yr. Most of this increase, according to the Insurance Department of the Chamber of Commerce, is directly attributable to the excellent results which have been secured in reducing infant and child mortality.

Credit, of course, must be given to the medical profession for the great share of this increase in the span of human life. We are, however, prone to believe that a considerable share of the credit is due to the application of mechanical power to human labor, which has been growing by leaps and bounds since the middle ages. As we study the methods employed in past centuries for conveying heavy materials, shoveling coal and ores, digging ditches and trenches and other working conditions to which the human beings were subjected for long hours daily, we cannot help comparing those conditions with the life of the average industrial worker in the United States today, where the great large share of his heavy labor is now done by machinery, thus relieving the human race of the strains which it endured in past centuries.

Not alone in industry, but also in the homes, do we

find that the power plant has made possible living conditions which are more conducive to longevity than those existing before the days of electric power. During the past quarter century, for example, the old hand-scrubbed washboard has practically disappeared from the homes of the American citizen. With it has also disappeared "blue Monday" with its back-aches for the many housewives of the country. We cannot neglect to mention the benefits to health which are derived from the vacuum cleaners which now occupy a place in nearly every home. Probably the greatest cause of contagion is due to germ-laden house dust. Not only contagious diseases, but practically all pulmonary troubles are aggravated by dust raised during the old process of sweeping with a corn broom. With the vacuum cleaner, however, not only is the dust prevented from rising into the atmosphere, but more of it is removed from the rugs, upholstery, walls and curtains than was formerly possible, and there is not the likelihood of so much dust getting into the air due to persons walking or playing on the rugs. Many diseases have also been traced to defective vision and impure air from the old time lamp. Here again, by better methods of lighting, electricity has played a great part in relieving the human body of ills and pains.

From the above-mentioned report it would seem possible with continued advance in our customs and living conditions to increase this life to 65 yr., which, authorities say, is eventually possible. What the power industry can do in shaping these living conditions is by no means a small item.

Results Possible Even with Old Equipment

Old plants are generally passed up because it is believed there is nothing to be learned in visiting them. Recently on visiting a plant which has been running for many years in Dayton the chief engineer was found at his desk reading a technical magazine and apparently perfectly assured that everything was running properly.

It was not odd, therefore, to find in the above plant one that was running smoothly. Everything had been so organized that this plant could be efficiently run 24 hr. a day by a chief engineer assisted by three young operating engineers. The water turbine, which was of the horizontal type, after running continuously for 40 yr., was supplied with a new shaft and bearings and continued as motive power. Two generators, one of 125 kw. operating at 600 r.p.m. and the other of 75 kw. running at 900 r.p.m. are running on their original bearings. After the Dayton flood, the armature of the former was taken out, cleaned and returned; one coil of the latter was replaced at the same time.

Not only was this plant thoroughly equipped with indicating and recording instruments but care had been exercised to install safety devices so as to avoid derangement or damage to vital parts. Inspection of operating parts is systematically and carefully made and constant care exercised.

Although the chief is 66 yr. of age and has had a thorough experience as an operating engineer, he was not above keeping in touch with what is done in the power plant field. He has ample time to keep posted because he understands the art of management as well as the subject of power plant operation.

Scientific Budgeting Is Now Possible

As a rule, the engineer in his endeavor to explain a profound theory is careful to start from a sound foundation with some basis of fact. If later he wanders off this foundation or builds a topheavy structure which topples over and lands him in a quagmire, as is unfortunately only too often the case, he should at least be given credit for a good start.

It is, therefore, with something akin to awe that we look at our newest and youngest brother, the business engineer, start with nothing, go nowhere and yet before our eyes erect a solid structure. It is not, however, until after wandering around the marble halls and gaining a little confidence that our natural curiosity about the power plant leads us down to the lower regions to discover that there are no lower regions but the building is suspended in air apparently by the same substance used to inflate the early type balloons exhibited at country fairs.

Perhaps it is only our timidity of height that urges us down to view the structure from a safe distance and wonder if, after all, business men like women, fools and children, are not under the special protection of Divine Providence.

By determining the trends and movements of business over a period of years, a well known business service sent out several formulas because, "Nothing short of a scientifically built budget is safe and nothing short of it should satisfy the demands of a modern business man" while, "making a budget is too often a matter of imagination.

"1. $1925 + 1926 \div 2 = 1927$
2. $1919 + 1923 + 1925 + 1926 \div 4 = 1927$
3. $1920 + 1926 \div 7 + 10\% = 1927$
4. $1919 + 1926 \div 8 + 9\% = 1927$

"Having applied the formula to one of the sets of figures representing your activity, you now find yourself with four results for the four separate formulas just given. You will now add the four results and divide the answer by four. This operation presents to you a figure which represents your normal for 1927."

A weighty and scientific method of saving the business man from ruin and we marvel that up to the time of its inception business was possible at all. Lest, however, we be accused of being critical, it may be well to remember that rule of thumb methods have not disappeared entirely in the technical field, empirical formulas are being fitted to experimental data, geologists write learned theses on formations after oil wells have been drilled or mine shafts sunk.

Some may even remember when a famous electrical engineer proved mathematically that radio telegraphy was impossible and another authority on hydraulics proved, also mathematically, that the efficiency of a centrifugal pump could never exceed 50 per cent.

Taken all in all, we are hardly in a position to criticize other branches of self styled, self evident or implied science but surely that should not prevent us from interrupting our monotonous contemplation of the dollar chasing the B.t.u. around the power plant, to view the antics of our contemporaries, especially if it puts us in a good humor and acts as a gentle reminder that perhaps after all some of the things we ourselves do in all seriousness may not stand inspection when viewed from some other angle.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New Anchoring Method for Monolithic Furnace Lining

TO ALLOW a one-piece monolithic furnace wall to move in any direction with expansion and contraction, providing for the difference in expansion and contraction between the common brick and the refractory

HOOK IS SECURED IN BRICK WALL AND AS WALL OF PLASTIC REFRACTORY IS BUILT UP ANCHOR IS PLACED OVER HOOK AND EMBEDDED IN PLASTIC MATERIAL

lining, a device known as the "flexo-anchor" has recently been developed. The flexo-anchor is designed at the same time to anchor the refractory to the common brick wall and to prevent bulging. The accompanying illustration shows the method of using this device, for which patents have been requested.

Plibrico Jointless Firebrick Co., Chicago, Ill., the manufacturer of this device, introduced the rigid anchor about 3 yr. ago. Three years of use under boilers of all types proved this rigid anchor successful, the manufacturer states, and the flexo-anchor is a further refinement and development of it to secure the advantage of allowing for expansion. As shown, the new anchor is a simple device. The hook is secured in the common brick wall, then, as the wall of plastic Plibrico is built up, the anchor is placed over the hook and, as the wall rises, the anchor is embedded in the plastic refractory. The anchor can be used in both new settings and repair jobs.

Each drum of the jointless Plibrico furnace lining now shipped by the company contains a flexo-anchor with full directions for installing it. It is fully described and illustrated in the new 36-page catalog entitled "Cutting Furnace Costs," which may be obtained from the company.

Homeyard Valve for Control of Hydraulic Equipment

IN THE OPERATION of hydraulic machinery the importance of having an operating valve that will not leak or stick and that will give accurate and smooth control is well recognized. To perform this service the

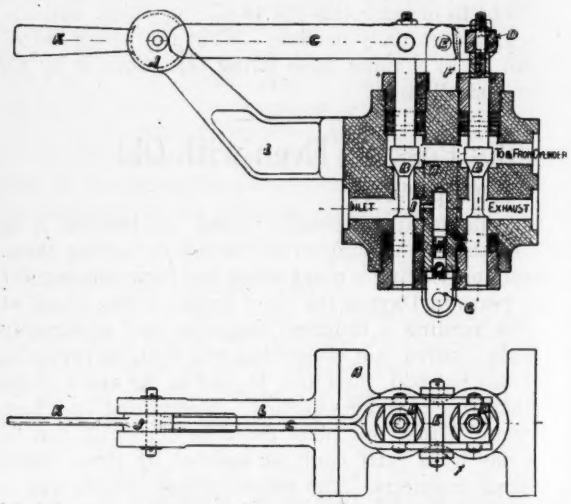


FIG. 1. SECTION AND BOTTOM VIEW OF SINGLE PORTED HYDRAULIC VALVE

latest type of Homeyard hydraulic valve, shown in the accompanying illustrations, has been developed by Messrs. Glenfield and Kennedy, Ltd., Kilmarnock, Scotland, and designed for use at pressures of 5000 lb. per sq. in. or over without any leakage. This Homeyard valve is supplied in two general types, the double-ported and the single-ported, the latter shown in Fig. 1. In the single-ported type the body, for most ordinary pressures, is of gunmetal bored out to receive two gunmetal spindles, one of which acts as a pressure valve and the other as an exhaust valve, the two spindles being coupled at the top by a connecting lever and crossheads.

Midway between the two spindles a pin and two side links are fitted to the lever, the links passing down the sides of the valve body to the lower portion, being connected together at their bottom ends by a gunmetal

crosshead. To this crosshead is connected a small ram, the cylinder of which is bored out of the valve body. The hydraulic supply for this ram is taken from the inlet branch of the valve.

In this way a constant downward thrust is exerted on the small ram and this thrust is transferred through the side links and lever to the valve spindles. Since the spindles themselves have pistons of exactly the same size at top and bottom and are, therefore, in equilibrium, the constant thrust from the ram tends to keep the valve closed. The valve lever is rounded at its outer end and fits into a recess formed in the cam lever, the rubbing surface being case-hardened.

For the highest pressures for which this valve is made, it is constructed of a solid block of forged steel, with seats and spindles of nickel steel or other highly resistant alloys.

In operating the valve the handle is moved up or down, thus moving the end of the valve lever in the opposite direction and raising one or other of the valve

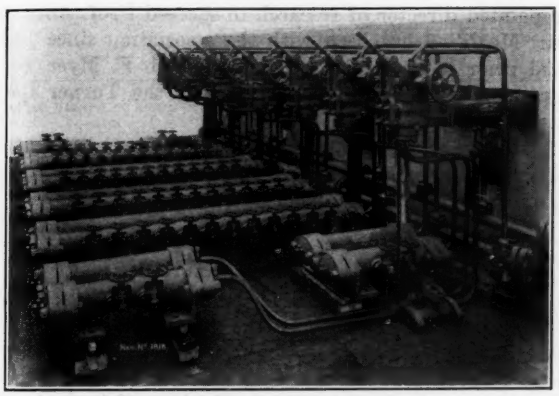


FIG. 2. EIGHT 1-IN. DOUBLE PORTED VALVES CONTROLLING HEADERS AT 1000 LB. PRESSURE

spindles, the one resting on its seat forming the fulcrum for the time being. If the handle is raised or lowered sufficiently it throws the end of the lever out of the recess in the cam, thus locking the valve in the open position. As soon as it is moved back, however, the ram brings both lever and handle to the mid-position, closing both spindles to their respective seats.

The valve is designed to work easily on account of the balancing of pressures and to give close and accurate control of the fluid. It is stated that the smaller sizes, for pressures of less than 1000 lb., may be controlled by the finger and thumb only. Figure 2 shows a group of eight 1-in. valves of the above type, except that they are double ported, controlling headers at 1000 lb. pressure.

Federal Trade Commission Reports on General Electric Co.

IN A REPORT MADE ON February 23 to the Senate by the Federal Trade Commission, Washington, D. C., it is shown that the General Electric Co. has divested itself of the great bulk of its financial interests in various electric power companies.

This report is the result of an investigation of the electric power industry authorized in 1925 by a resolution introduced in the United States Senate. At that time it was charged that the General Electric Co. had acquired and was exercising a very extensive control over the electric power industry.

The report of the Federal Trade Commission declares that the General Electric Co. in its stockholders' lists in October, 1926, showed no dominating stockholders in either the Electric Bond & Share Co. or the General Electric Co. and no common directors. The decision to give up control of the Electric Bond & Share Co. was made by the General Electric Co. on December 30, 1924. There have remained, of course, several interlocking directorships in which General Electric directors held similar positions in other companies but the report states that there was no apparent indication of exercise of much influence in the latter's affairs.

The report calls attention to other important electric power groups which it says in 1924 far exceeded in the aggregate the General Electric group. It also mentions the extent to which pyramiding has been carried in some of the power groups in superposing a series of holding companies over the underlying operating companies.

Allis-Chalmers Receives Order for State Line Condensers

ALLIS-CHALMERS MFG. CO., Milwaukee, Wisc., has just received an order for the largest surface condenser equipment ever placed for one generating unit. These condensers are for the State Line Generating Co. for use in connection with a 208,000-kw. turbine unit consisting of one high pressure and two low pressure turbines. The two low pressure turbines are each double flow and two condensers are required for each set of low pressure wheels, making four condensers for each low pressure turbine or eight condensers in all.

Each of the eight condensers will contain 22,000 sq. ft. effective cooling surface, or 176,000 sq. ft. in all. The eight condensers will be designed to handle 1,600,000 lb. of steam an hour and are supplied with 360,000 g.p.m. of circulating water from four vertical circulating pumps placed in a crib house located outside the generating station. The condensers are of the vertical single pass type, the circulating water entering through the lower water box, passing through the condenser tubes and then being discharged through overflow pipes contained in the condenser shell. This arrangement eliminates unsightly circulating water piping, as with the usual standard arrangement the discharge piping would be placed outside of the condenser in the turbine room.

Condensate will be collected in hotwells and delivered against 250 lb. gage pressure by six 3-stage condensate pumps, each rated 1000 g.p.m. Air removal equipment will consist of 2-stage steam jet air pumps, the first stages being attached to the condenser shell and the second stages grouped with the surface inter and aftercoolers.

THE ALUMINUM CO. OF AMERICA, Pittsburgh, Pa., plans to carry out two hydro-electric developments in North Carolina during the present year, to be located at Santeetlah and Badin, where sites were secured a number of months ago. These plants will supply power for the company's operations in this district.

Senate Resolution Asks Investigation of Power Industry

By Wingrove Bathon

SENATOR WALSH of Montana has offered in the Senate a resolution, which does not require approval by the House of Representatives, for the creation of a special committee of five members of the Senate to investigate the electric power industry and the gas industry in their financial aspects.

It is no secret in Washington that some representatives of the electric power industry welcome this investigation. A number of power company executives have visited Washington recently, calling on Senator Walsh, as well as representatives of investment bankers and other organizations closely in touch with the electric power industry. Many of these visitors to Washington believe the Walsh resolution will give good opportunity for the electric power industry to show that it is a clean industry, with the exception of a few instances of bad practice in financial structure, and it is believed that the result of the investigation, if made, will materially assist in eliminating such bad practices and those responsible for them from the industry.

The language of the resolution, which would give broad powers to the proposed committee, is as follows:

"Resolved, That a committee of five members of the Senate be appointed by the President thereof, hereby empowered and directed to inquire into the growth of the capitalization of public utility corporations supplying either electrical energy in the form of power or light or both, however produced, or gas, natural or artificial, and of corporations holding the stocks of such corporations, the method of issuing and the price realized or value received for the various security issues of both classes of corporations named, including the bonds and other evidences of indebtedness thereof, as well as the stocks of the same, the extent to which additions or extensions to the property of the operating companies have been made, and the value or detriment to the public of holding companies owning the stock or otherwise controlling such operating companies immediately or remotely, with the extent of such ownership or control and particularly what legislation, if any, should be enacted by Congress to correct any abuses that may exist in the organization or operation of such companies."

The resolution also carries provisions allowing the committee to sit this summer while Congress is not in session, to employ counsel, experts and assistants, as well as stenographers; to administer oaths; to subpoena witnesses, with provision for punishment for refusal to appear or testify, and to require the production of books, papers and documents.

Senator Walsh delivered a lengthy address to the Senate on February 28 in connection with his resolution. His desire for the investigation proposed is the outgrowth of recent magazine articles in the Atlantic Monthly by Prof. William Z. Ripley of Harvard University, concerning the intricacies of financial structures which have more than one class of stock, among them non-voting stock sold to the public while permanence of control is held by "insiders."

Editor's Note.—No action on this resolution had been taken up to time of adjournment on March 4.

Prof. Abrams Resigns from Portland Cement Association

Portland Cement Association, Chicago, Ill., announces with regret the resignation of Duff A. Abrams, for many years the director of its research laboratory. Professor Abrams inaugurated the present-day research in concrete when he took charge of the Structural Materials Research Laboratory in 1916. The program then instituted was supported by the co-operation of Lewis Institute and Portland Cement Association and was continued until May, 1926, wh the research laboratory was installed in the new headquarters building of the Portland Cement Association in Chicago.

Professor Abrams' work in concrete researeh is known throughout the world. His bulletins and scientific papers have been translated into many languages and are considered standard reference works in concrete technology.

F. R. McMillan, manager, Structural and Technical Bureau of the Portland Cement Association, has been appointed director of research to succeed Prof. Abrams. Mr. McMillan has been with the association since 1924 and prior to that time was with Adolph F. Myer, consulting hydraulic engineer, and with the Turner Construction Co.

H. F. Gonnerman, associate engineer, research laboratory, Portland Cement Association, has been appointed director of the laboratory.

Coal Classification

Sponsorship for the development of a plan for the classification of coals under the American Engineering Standards Committee, has been accepted by the American Society for Testing Materials.

All coals from anthracite to lignite will be included in this classification which will be based upon such chemical and physical characteristics as will make the plan most readily adaptable to industrial and commercial use on a national scale. This project originated in a proposal submitted to the American Engineering Standards Committee by the Coal Mining Institute of America and was agreed upon for development at a conference of delegates from representative organizations held in Pittsburgh in November, 1926.

The Society is now engaged in the formation of a sectional committee upon which 25 national organizations, including Federal bureaus, broadly representative of coal operators and dealers, consumers and the general public, will be represented.

At a meeting in Pittsburgh on February 25, the steering committee outlined a tentative plan of organization and arranged for the preparation of a comprehensive review of the present status of coal classification for presentation to the sectional committee when organized.

Creation of a Farmers' Federated Fertilizer Corporation and the lease of the Muscle Shoals project to this corporation was proposed in House Bill No. 17392, introduced in the House by Representative Reece, of Butler, Tenn. Under the bill the lease would exist for 55 years or until 5 years after the termination of operation by the corporation under the terms of the Muscle Shoals proposal.

Marked Improvement in Utilization of Fuel in 1926

TOTAL ANNUAL PRODUCTION of electricity by public utility power plants in 1926 was 73,398,000,000 kw., an increase of 11.4 per cent over the output for 1925. Of this quantity about 35 per cent was produced by the use of water power, an increase of 1 per cent over that for 1926. Electricity produced by the use of fuel increased 9 per cent, and electricity produced by water power increased 16 per cent. It would have required more than 25,000,000 t. of coal to generate the electricity produced by water power, according to a report of the Geological Survey, Department of the Interior.

There was a marked improvement in efficiency in the utilization of fuel in the production of electricity by these power plants in 1926. Although the increase in output by the use of fuels was 9 per cent, the increase in fuel consumption was only about 2 per cent. The average rate of consumption of coal in 1926 was 1.95 lb. per kilowatt-hour, showing a gain in efficiency of about 8 per cent during the year.

To have produced the electricity generated by the use of all fuels in 1926 by the use of coal alone would have required 46,400,000 t. at the average rate of coal consumption in 1926, or 76,000,000 t. at the average rate in 1919—a difference of nearly 30,000,000 t. This figure indicates the immense saving in coal brought about by the improvement in the design and operation of public utility power plants since 1919. At the present time at least one plant is using only about 0.85 lb. of coal to produce a kilowatt-hour of electricity. If all the electricity produced by electric public utilities in 1926 by the use of fuels had been produced by the consumption of 0.85 lb. of coal per kilowatt-hour, the conservation of coal would have amounted to 26,000,000 t., which is equivalent to about $100,000,000.

The accompanying table shows the number of electric public utility power companies, the number of plants, the capacity of the generators on January 1, 1927, the total production of electricity divided between water power and fuel power, the consumption of fuels for 1926 for the United States and groups of states.

Report of the Geological Survey, Department of the Interior, for March 4, 1927, on the production of electric power by public utility power plants in the United States gives figures including January, 1927. The total production for that month was 6,714,458,000 kw-hr., an increase of 10 per cent from January, 1926.

In January, 1927, the total coal consumption for the United States was 3,801,343 short tons. In addition, 782,829 barrels of fuel oil were burned, together with 3,865,985,000 cu. ft. of natural gas.

The average daily production of electricity by public utility plants during January was 216,600,000 kw-hr., a decrease of about 1 per cent from the revised figure of average daily output for December, which was 219,200,000 kw-hr. A total of 1,503,173,000 kw-hr. was exported from Canada into the United States during 1926 and 3,230,000 kw-hr. were sent to Canada.

TABLE SHOWING ANNUAL PRODUCTION OF ELECTRICITY AND FUEL CONSUMPTION BY U. S. PUBLIC UTILITY POWER PLANTS IN 1926

	Companies and Plants			Output (Thousands of Kilowatt-hours)				Fuel Consumption		
	Number of Companies	Number of Plants	Capacity a/ in Kilowatts	Total	Water Power	Fuel Power	By use of Wood b/	Coal (Net tons)	Oil (Barrels)	Natural gas (M cubic feet)
United States	2,058	3,807	25,256,556	73,398,314	25,935,920	47,462,394	325,424	41,303,985	9,375,681	50,852,855
Geographic Divisions:										
New England	185	340	2,338,739	5,162,129	1,683,918	3,478,211	0	2,781,455	920,339	0
Middle Atlantic	256	465	6,606,943	20,290,840	5,812,709	14,478,131	0	12,753,143	351,899	147,821
East North Central	414	785	5,907,831	17,642,168	2,055,973	15,586,195	1,785	15,016,875	47,582	5,079,733
West North Central	422	708	1,896,458	4,586,771	1,515,143	3,071,628	8,717	3,575,398	975,184	5,906,362
South Atlantic	253	407	2,814,919	7,178,251	2,070,067	5,108,184	7,349	4,180,179	2,280,279	157,302
East South Central	110	203	1,226,973	3,065,917	1,941,189	1,124,728	1,873	1,335,140	62,457	40,242
West South Central	176	340	877,169	2,511,084	48,749	2,462,335	5,908	966,943	1,778,113	28,995,506
Mountain	151	277	877,418	3,424,442	2,833,869	590,573	12,117	680,919	264,385	159,379
Pacific	91	282	2,710,106	9,536,712	7,974,303	1,562,409	287,735	13,933	2,695,443	10,366,510

a/ January 1, 1927.

b/ Included in fuel power.

Engineers Public Service Co. Report

LARGE INCREASES in consolidated gross and net earnings are shown by Engineers Public Service Co. in its annual report for 1926 issued to stockholders, according to a statement by Stone & Webster, Inc. Gross earnings were $26,627,687, an increase of $3,518,750 over the figures in the previous annual report and balance available for reserves and the 778,938 outstanding shares of Engineers common stock increased 25.9 per cent to $3,183,879. The report gives several detail analyses including capitalization totaling $4.92 per $1 of gross, maintenance expenditures amounting to 9 per cent of gross, and reserves and surplus equaling 72 per cent of annual gross earnings. The company reports, in addition to the acquisition of Baton Rouge Electric Co., net increases in plant of its subsidiaries totalling $15,077,000 and the reinvestment of $3,391,455 of earnings in the properties.

The subsidiaries serve a population of 1,176,100 and have total generating capacity of 259,800 kw. with output in 1926 of 637,474,000 kw-hr. The Eastern Texas Electric Co. has completed the initial installation of 25,000 kv.a. in a new power station and extended its lines into a large portion of southern Louisiana. The increased earnings of the El Paso, Savannah and Key West properties also reflect the healthy growth of industry in the territories served.

News Notes

HEINE BOILER Co., St. Louis, Mo., announces that beginning March 1, 1927, its New York sales and engineering offices will be located in the International Combustion Bldg., 200 Madison Ave., New York City.

YARNALL-WARING Co., Philadelphia, Pa., announces that G. G. Sutton joined its organization on Feb. 15 as southern district manager, succeeding Samuel D. Barr, who will be in charge of the Detroit-Cleveland territory.

LINK-BELT Co., Chicago, Ill., announces the opening on March 6 of a new branch sales office at 229 Brown-Marx Bldg., Birmingham, Ala., in charge of W. H. Norton, formerly of the Chicago sales department, assisted by Harold R. Haught.

BOTFIELD REFRACTORIES Co., Philadelphia, Pa., announces that Frank J. Donnelly has joined its New York office and will cover the New Jersey territory under the direction of Chas. C. Phillips, New York district manager.

THE FALK CORP., Milwaukee, Wis., announces that Arthur Simonson has been elected a vice president of the corporation. Mr. Simonson has been sales manager of the steel foundry department since 1916 and has been with The Falk Corp. since 1910.

THE DAMPNEY Co. OF AMERICA, Hyde Park, Boston, Mass., announces that the sales of its Apexior protective coating for power plant equipment will be handled in the Chicago district by D. H. Skeen & Co., Monadnock Bldg., Chicago.

ELLIOTT Co., Jeannette, Pa., announces that C. J. Carle, who was secretary-treasurer of the Lagonda Mfg. Co., Springfield, Ohio, died on Sunday morning, Feb. 6, at the age of eighty. Mr. Carle has been associated with the projects of W. S. Elliott, president of the Elliott Co., for more than a quarter of a century.

IN THE ANNUAL REPORT for 1926 to the stockholders of the Duquesne Light Co., which serves the greater Pittsburgh district, President A. W. Robertson states that electrical output and number of new customers have increased more than 8 per cent, that both gross and net earnings increased proportionately and that during the year $8,733,600 was invested in additions and improvements to the service.

TRICO FUSE MFG. Co., Milwaukee, Wis., has just appointed B. M. Slicting as sales promotion manager with headquarters at the main office in Milwaukee. It has also appointed J. E. Eldredge, of South Windsor, Conn., as sales representative for Connecticut and western Massachusetts, and Arthur E. Bacon, Denver, Colo., for the states of Colorado, New Mexico, Utah and Wyoming.

FOR THE 208,000-KW. turbo-generator ordered by the State Line Generating Co. for the new power station to be erected on the shore of Lake Michigan immediately east of the Illinois-Indiana state line, steam will be supplied by six Babcock & Wilcox boiler units built for 800 lb. working pressure with superheaters, economizers, air heaters, Bailey furnaces and burners, and Fuller-Lehigh unit-mill pulverized coal equipment. The order for this entire equipment has been placed with the Babcock & Wilcox Co. The boiler units are similar in design but somewhat larger than the B. & W. pulverized coal boiler unit that has been in service since November in the Calumet station of the Commonwealth Edison Co. of Chicago.

THE PHILADELPHIA ELECTRIC Co., Philadelphia, Pa., and the Pennsylvania Power & Light Co., Allentown, Pa., have arranged for a consolidation covering interchange of power creating what is said to be the greatest unit power system in the world, designed for an ultimate generating capacity of 2,000,000 hp. The agreement provides for the building of a new 220,000-v. transmission line to connect the two properties. The entire transmission system will reach from the new hydro-electric plant at Conowingo to the Siegfried substation of the Pennsylvania company, connecting there with mine-mouth power stations and with the new hydro electric plant at Wallenpaupack.

AMERICAN ENGINEERING Co., Philadelphia, Pa., announces the appointment of Joseph G. Worker as general sales manager of the company and his election to the board of directors. Mr. Worker is a graduate of the University of Illinois; member of the A. S. M. E.; former president of the Stoker. Manufacturers' Association and writer of many articles on combustion engineering. For 15 yr. he was associated with the Westinghouse Elec. & Mfg. Co., having been manager of the stoker section at East Pittsburgh for the last 5 yr. of this period. During the past 5 yr. he has served as assistant to the president of the American Engineering Co.

THE ASSOCIATED GAS & ELECTRIC Co., New York, has acquired a controlling interest in the Cambridge Electric Light Co. and plans expansion throughout the Cambridge district and neighboring territory of the country which will be under the direction of the J. G. White Management Corp.

GEORGE L. BLACK, formerly of the Wakefield Gas & Electric Co., Wakefield, Mass., has been appointed manager of the sales department of the Rockville-Willimantic Lighting Co., Willimantic, Conn.

RUSSELL ROBB, senior vice-president, treasurer and a director of Stone & Webster, Inc., Boston, Mass., died at the Massachusetts General Hospital in Boston, Feb. 15. He was a graduate of the Massachusetts Institute of Technology in 1888, was first manager of public service corporations for Stone & Webster, was admitted to the firm in 1905 and was made vice-president and treasurer when the company incorporated in 1920. He was a director of more than a score of power, light and public service corporations along the Atlantic seaboard and the Gulf of Mexico.

IN HIS ANNUAL REPORT to the stockholders of the Timken Roller Bearing Co., Canton, Ohio, H. H. Timken, president of the company, says, "Timken bearings are now used extensively in 300 different kinds of machinery. During 1926 we completed experimental work on three new types of Timken bearings and began to introduce them in the trade: a line of large bearings for heavy duty in steel mills, rolling mills, sugar mills, cement mills, etc., ranging in size up to 35 in. in diameter; second, a line of "all thrust" bearings adapted to special machinery, pivots, crane hooks, and the like; and, third, a line of double bearings, self-contained for certain types of electric motors, turbines and pumps.

"During 1926 we sold profitably about double the tonnage of electric steel sold during the previous year. About 500 Timken-equipped railroad cars driven by gasoline engines for special service have been in operation on all the principal railroads for several years. Last year our first large order for passenger car bearings was obtained for 63 new Pullman cars and 64 company-owned cars from the Chicago, Milwaukee & St. Paul R. R., making 12 complete trains. Report shows net profits from sales with other net income of $8,474,103 after ample reserve for depreciation and for United States income taxes. Cash dividends of $5,403,969 were paid during the year and a balance of $3,045,120 was transferred to the surplus account."

THE SUPERHEATER Co., New York City, announces the death on Feb. 21, 1927, of William F. Clark, an erector of stationary superheaters for the company.

Mr. Clark was born at Laddonia, Mo. in 1882. Although he had only a common school education, he prepared himself for his work through earnest personal effort and intensive application to the problems of erection and operation of combustion and power plant equipment. He was with the Green Engineering Co. of Chicago for 20 yr., then with the Brady Foundry & Machine Co. and the American Arch Co., joining The Superheater Co. in September, 1925.

AT ITS MEETING on March 3 the Federal Power Commission, Washington, D. C., authorized amendment of a license now outstanding in favor of the Washington Irrigation & Development Co. This license was amended to defer construction for two years of the Priest Rapids project of the Washington Irrigation & Development Co., which was to have begun on March 5, 1927 and completed to a capacity of 220,000 hp. by Dec. 31, 1931. The postponement was made in order to enable the company to prosecute further its studies of market conditions for the power proposed to be developed under the license.

THE EAST TEXAS PUBLIC SERVICE Co., Marshall, Tex., has approved plans for the building of a new group of ice manufacturing plants and cold storage plants, including a 20-t. plant at Winnsboro, a 40-t. plant at Carthage and several others.

THE WEST VIRGINIA POWER & TRANSMISSION Co., Pittsburgh, Pa., is making plans for a hydro-electric plant on the Cheat River near Morganstown, W. Va., including two connected stations with capacities of 60,000 and 48,000 hp. respectively.

FOLLOWING APPLICATIONS have been filed with the Federal Power Commission during the four weeks' period ending March 5, 1927:

The Mt. Shasta Power Corp. has applied for a license for an 11-mi. transmission line affecting Indian lands in Lassen National Forest in Shasta County.

The Utah Power & Light Co. has applied for a license to build an 82-mi. transmission line from the Wheelon switchyard to the Idaho Power Company's American Falls plant.

R. H. Woods has applied for a preliminary permit to build five storage reservoirs and power plants on the Gila river, in Hidalgo and Grant counties, New Mexico. It is planned to develop 50,000 hp. for use in mining and for public utility purposes. At the time of filing, this application conflicted with the preliminary permit then outstanding in favor of the American Alum Corp., which has since been withdrawn. In the Commission's sixth annual report, reference was made to its record of decisions on declarations of intention under section 23 of the Federal water power act, together with other important matters. A few copies of this report remain on hand for sale at $1.00 each, which is the cost of reproduction.

MEMBERS OF CONGRESS and others interested in development of the water power possibilities of the Muscle Shoals and Boulder dam projects decided at a conference on March 11 to conduct a publicity campaign to acquaint the public with all the facts regarding those properties and to combat the opposition which they allege has been inspired by electric power companies. This was announced by Senator Johnson (Rep.), of California, after the conference. Mr. Johnson was one of the authors of the bill for government development of the Boulder dam project.

WATER PURIFICATION and softening will be discussed by C. P. Hoover, a recognized authority and consultant on that subject, before the Industrial Division of the American Chemical Society at its meeting in Richmond, Va., April 11 to 16, when three half days will be devoted to a symposium on lime. In the process industries the quality of the water may be a determining factor in the success or failure of the process and results of extensive tests on many of the specific problems will be presented and their relation to industrial and domestic problems discussed. Results of an extensive series of tests conducted to develop an economical and durable heat resisting water paint or whitewash will be presented.

AT ITS MEETING on March 4 at the Engineering Societies' Building, New York City, New York Chapter No. 2 of the National Association of Practical Refrigerating Engineers heard two interesting and valuable papers; one by Chas. H. Herter on "The Protection of Insulation Against Moisture"; the second by Van V. Gildersleeve, of the Atlantic Paint Co., New York, on a rust preventing solution produced by his company. Further details of these papers will be presented in the near future.

PLANS FOR THE proposed powerhouse to be erected on city owned property for the development of one-half of the excess flow of the Oswego river at Dam Number 6 have been approved by the Water Service Commission. Advertising for bids on leasing the water power and to include the building of the plant has been started.

Plans as prepared by Frank M. Williams of New York, former state engineer who has served as consulting engineer to the local commission, provide for a hydro-electric plant capable of developing 7500 hp. The plant will be equipped with three generating units of 2500 hp. each. The plans provide for a plant that may be doubled in size in the event the city should eventually acquire the river to develop the full flow of water at the dam.

AT A GATHERING of New England business men on March 12 at New Haven, Conn., Herbert Hoover, Secretary of Commerce, stated that a shipway between the Atlantic and Great Lakes by way of the St. Lawrence would open the whole of the mid-continent to international trade, substantially increase the returns from

farming by lowering transportation costs and benefit the industrial east by development of power.

The secretary said that since the commission of engineers pronounced the canal construction feasible a strong tide of sentiment for immediate construction has been evident. He also stated that there might be some obstacles in the way of putting such a plan into effect but that the long record of successful co-operation between the United States and Canada left him extremely hopeful of an agreement on the subject.

THE HOUSE COMMITTEE ON MILITARY AFFAIRS, on March 3, at a final meeting for this Congress, unanimously agreed on a report rejecting proposals for disposition of the Muscle Shoals property, as embodied in the two bills pending before the Committee. The report stipulated principles and limitations to be held fundamental in any proposed legislation submitted to the next Congress.

It says that unless a satisfactory bid is received by the time the next Congress convenes in December an effort should be made to obtain an operating contract for fertilizer production at Muscle Shoals and in default of that the House Military Affairs Committee should consider operation of Muscle Shoals by a Governm.ent corporation.

The Committee also agreed that the Federal Power Commission should not grant a preliminary permit at Cove Creek, or at any other point affecting the Muscle Shoals project, until after expiration of next session of Congress, and it requested the Secretary of War to allot funds for a preliminary survey of the Cove Creek dam proposal.

THE BROWN INSTRUMENT CO., Philadelphia, Pa., has appointed L. C. Wilson to handle sales and engineering service in the distribution of the new Brown electric flow meter in the Pittsburgh territory.

Catalog Notes

DEAERATING HEATERS for preventing oxygen corrosion are described in bulletin No. 672 just published by the Cochrane Corp., Philadelphia, Pa. This publication discusses heat balance in power plants; the use of surface and open heaters; and particularly deaerating heaters and regenerative feed water heating systems. Numerous heat balance hookups are shown for both central stations and industrial plants. Discussion is given of prevention of oxygen corrosion, water treatment, tests of deaerating heaters, and the like, together with many illustrations of details and installations.

CIRCULAR 1771, Oil Circuit-Breakers, Types B-16, B-20, and B-26, has just been issued by the Westinghouse Electric and Manufacturing Co. This 12-page publication describes the application, construction, operation and other distinctive features of these types of breakers. This is a new publication and is well illustrated with halftone cuts of the various types of units described.

WALTER BATES STEEL CORP., Gary, Ind., in a 4-page leaflet describes floor grating used in power plants and industrial buildings. A special method of interlocking the bars of this grating is used to provide a positive lock joint and to increase its strength.

DECELECO, INC., Wayne, Mich., in a recent 32-page illustrated catalog, describes Deceleco factory-made bus-and-switch cell structures. This bulletin describes various types of structures that can be built with slabs of "Zellite," which are supplied in various standard dimensions of uniform thickness.

SCHUTTE & KOERTING CO., Philadelphia, Pa., in its new bulletin 8-T, describes and illustrates the Schutte & Koerting piston valves (Klinger patents). In these valves, instead of flat or bevel seat faces, a cylindrical piston or plunger is used, sliding vertically through two special packing rings separated by a bronze lantern having ports through which the fluid flows when the valve is opened.

MIDWEST AIR FILTERS, INC., Bradford, Pa., in a new bulletin entitled "Midwest Detail Sheets" presents sketches and dimensions of its various filters and their elements for the use of designing engineers, together with information on how to determine the number of units required. It is also issuing a 4-page illustrated folder entitled "Filters for Compressors and Engines." These will be sent free upon request to the company.

CHARLES CORY & SON, INC., New York City, is now distributing its bulletin No. 60-29-A, describing annunciators, bells, buzzers and signal equipment. This describes equipment for manually and automatically operated visible and audible signals for routine communication as used in marine and industrial work, with a special section devoted to central station annunciators.

WHITING CORP., Harvey, Ill., has recently sent out a Nielsen survey covering an installation of Whiting bucket cranes used by Union Gas & Elec. Co., Cincinnati, O. These are used for coal handling at the West End power plant of this company with operating costs of $0.06 per ton of coal handled. The total cost of repairs and maintenance during the sixth and seventh years of operation of boiler house cranes was $0.0125 per ton of coal handled.

THE PICKERING GOVERNOR CO., Portland, Conn., in catalog No. 27, which it has just issued, illustrates and describes Pickering governors. These are of the centrifugal type, designed for close regulation and high efficiency. The ball ranger speed changer device aids in regulation of speed by this governor, which operates directly on the control valve. It can be supplied with automatic safety stop or combined stop valve and in either horizontal or vertical types, for steam engines, turbines and water wheels. Dimensions, prices and details of installation are shown in the catalog.

CLEVELAND TRAMRAIL SYSTEMS for the handling of products in industrial plants are described in the 4-page leaflet issued by the Cleveland Tramrail Division of The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

LEE B. METTLER CO., Los Angeles, Calif., in a recent 16-page illustrated bulletin describes and illustrates Mettler entrained combustion gas burners. These are designed for all kinds of gas and for any pressures and conditions.

"THE COST OF CONCRETE BOILER TUBES AND PIPING" is the title of a 4-page folder issued by The Refinite Co., Omaha, Nebr., discussing the heat losses due to scale and the advantage of softened water in preventing such losses.